

Situation-Based Testing for Ubiquitous Computing Systems

Supplemental Appendices

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Chapter 1

Introduction

This document includes supplemental appendices for the thesis entitled *Situation-Based Testing for Ubiquitous Computing Systems*.

Appendix G

State of the Art

Comparison Framework Analysis

G.1 State of the Art Analysis

This appendix provides an analysis of the tools surveyed in the state of the art review using the comparison framework defined in Chapter 3. The charted comparison framework, shown in Figure G.1, illustrates the four main sections of the framework, including tool design, deployment environment, testing and evaluation. Each of these categories are discussed in turn and describe the main contributions of the reviewed tools in terms of the framework's key criteria, and highlight some current gaps in the state of the art.

Shaded squares in Figure G.1 indicate which tools were discussed for each characteristic listed on the left-hand side of the chart. Darker squares illustrate where tools have been singled out for discussion in relation to a specific characteristic, in this appendix or in Section 3.7 of the thesis. Paler squares illustrate that a tool has been discussed in general terms, e.g. broadly in terms of the category to which it belongs.

		1999	1999	2002	2002	2002	2004	2005	2005	2006	2007	2009	2009	2010	
		Aware Home	Context Toolkit	Landscape	QuakeSim	UbiWise	Topiary	Paper Prototypes	Ubiquitous Home	UbiReal	VisualIRDK	SituVis	DiaSuite & DiaSim	AmISim	
Category:		Live (L) Simulation (S) Prototyping (P)													
		L	P	L	S	S	P	P	L	S	P	P	S	S	
Tool Design	Reusability	●	●	●	●	●	●	●	●	●	●	●	●	●	
	Extensibility	○	●	●	●	●	●	●	○	●	●	●	●	●	
	Context Generation	User	●	●	●	●	●	●	●	●	●	●	●	●	●
		Entity	●	●	●	○	●	○	●	●	●	●	●	●	●
		Location	●	●	●	●	●	●	●	●	●	●	●	●	●
	Toolkit		●			●	●				●		●		
	Test-bed	●			●	●				●	●		●	●	
Deployment Environment	Scalability	Physical Space		○	●	●	●		●	●	○	○	○	○	
		Entities	○	○	○	○	●	○	●	○	○	○	●	●	
		Users	○	○	○	○	○	○	○	○	○	○	○	○	●
	Heterogeneity	Context Sources	●	●	●	○	●	○	●	●	●	○	●	●	
		Environments	●	○	●	●	●	●		●	●	○	●	●	
	Configurability	○	○	○	●	●	●	●	○	●	●		●	●	
	Fidelity	●	○	●	○	○	○	○	●	○	○		○	○	
Low Investment	●	●	○	●	●	●	●	●	●	●	●	●	●		
Testing	Repeatability	○		○	○				○	●			○	○	
	Scalability	Time	●		○			○	●	○		○	○	●	
		Spatio-Temporal Relationship	●	○	●	●	●	○	○	●	○	○		○	○
	Spontaneous/Unanticipated Situations	●	○	●	○	○	○	○	●	○		○	○	○	
	Visual Monitoring	●	○	●	●	●	●	○	●	●	○	○	●	●	
	Automatic Monitoring									●	●		○	○	
Evaluation	Technical Effectiveness									○	○		○	○	
	Situational Appropriateness	●		●					●		○				
	Traceable Causal Factors												○	○	
	Structured Feedback														
Legend															
● Yes		Tool discussed in Section 3.7													
○ Partial		Tool discussed in Appendix G													
No		Discussed in general terms in Section 3.7													
		Discussed in general terms Appendix G													

Figure G.1: Comparison Framework Chart.

G.1.1 Tool Design

Reusability

Simulation tools generally score well in this category because resources are not only reusable but they can also be replicated or duplicated in order to increase the quantity of resources used during a simulation. Prototyping tools can be considered reusable as long the prototypes generated are not intended to be production-ready. In the case of production-ready prototypes, there is potential for resources to end up embedded or integrated in the live deployment, which may limit availability of resources for reuse.

Paper prototypes are not considered reusable because often the paper will need to be written on, torn, or changed in some other way, during an experiment. Live test-beds are generally reusable, i.e. Aware Home [1] or Ubiquitous Home [16], however live test environments are not, i.e. Labscape. Labscape was a once off, domain specific development, realised in the target deployment environment. It would be unsuitable and often incorrect to reuse the biologist's laboratory to develop other unrelated applications.

Extensibility

Simulation or model-driven tools are generally extensible because the code and models can be extended to include emerging technologies and a variety of environments. Live test-beds are listed as partially extensible because it is possible to add new technologies to these environments, but extending the physical environment is a significant undertaking and ultimately it is bounded by a finite amount of space. Paper prototyping is not listed as extensible because fundamentally as a tool it remains the same, i.e. the paper is unchanging with respect to ubicomp technology.

Context Generation

Live environments can rely on real physical sensors as a source of context. Simulation-based test-beds on the other hand use artificial sources of context. AmISim [9, 8] has demonstrated that a full context management system can be integrated with a simulation based test-bed to feature context management in addition to context generation. The Context Toolkit [13] provided not only one of the earliest examples of a context generator for prototyping but also an early example of hybrid context sources. This was achieved by interfacing live sensors, and later QuakeSim, with widgets in the toolkit which were used to construct applications. Paper prototypes do not need to provide sources of context because they are not computer-based prototypes.

Toolkits and Test-beds

Most of the tools in the review are classified as either a toolkit or a test-bed. Toolkits are beneficial because they make it easier for designers to convert ideas into interactive or computer prototypes. Test-beds are beneficial because they make it easier for designers to test computer prototypes.

Two of the tools are listed as both a toolkit and a test-bed, these are UbiWise [3, 2] and DiaSuite [10]. UbiWise, although technically addressing both, is an older tool and is correspondingly less sophisticated than some of the newer tools. DiaSuite also technically addresses both, however, while it offers a sophisticated toolkit, featuring an elaborate programming framework, the simulation-based test-bed, DiaSim, appears to be new research with many of its objectives still to be achieved.

G.1.2 Deployment Environment

Scalability

Simulation based tools generally score best in terms of scalability. Tools which feature two dimensional models of the environment are listed as partially scalable

in terms of the physical space because they do not maintain the fidelity of all three dimensions. Live environments are listed as partially scalable in terms of users and entities because these are usually finite resources for a researcher. UbiWise and QuakeSim are listed as partially scalable in terms of users because the underlying game engine places a limit of 16 players per game. Neither of these projects mention that they make use of artificial-intelligence (AI) based characters to increase this total. Topiary is listed as partially scalable in terms of users because its Wizard of Oz approach requires one shadow tester for each mobile test-user. Each shadow tester needs to be trained to use both Topiary and to imitate the prototype application, which has the potential to be prohibitive for scalability.

Heterogeneity

Diversity of context sources has generally been achieved across all of the surveyed tools to a certain extent. However, context is a vast and complex issue, as a result is it difficult to draw direct comparisons across all the surveyed tools, because of their varying motivations and objectives. The only exception, to heterogeneity of context sources, is paper prototyping, which does not need a context source since it does not produce computer prototypes.

Heterogeneity of the physical environment was only found in simulation-based tools. Live environments tend to be domain specific, i.e. the domestic setting of the Aware Home or the scientific laboratory in Labscape. The Context Toolkit [13] has some access to heterogeneous environments through its integration with QuakeSim, so it is included as partially offering heterogeneous environments.

Configurability

Most of the surveyed tools have configurable environments. Tools which use live test environments are listed as partially configurable because although it can be difficult to reconfigure the physical space, it is relatively easy to change the configuration of devices deployed in the physical environment.

Paper prototypes are not listed as configurable because neither devices or the physical layout of the deployment environment can be configured.

Fidelity

Live environments will always have the best fidelity in terms of the space and physical phenomena. Three dimensional simulators offer graphical fidelity and realism that can provide an immersive experience, as discussed by Trenholme [14]. For this reason, 3D virtual environments are classified as medium fidelity and are marked as partially satisfying environment fidelity.

Two dimensional environments offer lower fidelity because they cannot replicate the full spatial relations of the space. This is evident in DiaSim [10] where the authors discuss approximating physical phenomena in the environment as uniform across defined 2D polygon spaces. Two dimensional simulators are listed as partially offering environment fidelity, however this less sophisticated than 3D simulators, particularly for newer 3D simulation engines which often feature sophisticated physics engines.

Level of Investment

Simulation-based tools can be low-investment, however the extent of investment required is tied to the fidelity achieved by the simulator. High fidelity simulation models, i.e. visually and spatially accurate, require more effort than 2D wire-frame models. For example, it is likely that to create the same model in QuakeSim (3D) [5, 4] would require more effort than an equivalent model in DiaSim (2D) [10] or Topiary (2D) [11].

Simulators that use AI-driven users involve less investment of time at run-time. This is because experiments do not require supervision or user interaction during execution. AmISim uses multi-agent simulation, which does not require supervision, whereas UbiWise requires test-users to interact with the prototype during an experiment.

Live environments require the greatest investment in terms of both resources and time. In both the Aware Home [1] and Ubiquitous Home [16] reporting, the authors discuss experiments with users that run for weeks at a time. Paper prototyping [6], on the other hand, requires very low investment, particularly in terms of development time.

G.1.3 Testing

Repeatability

Repeatability of tests is an issue for live environments because the level of accuracy and exactness of repeated tests can be affected by noise in the environment and even minor deviations in user behaviour. A benefit of configurable simulation-based tools is that tests are more easily reproduced because there is less risk of interference from environment noise. Exceptions are simulations that only use randomness or probabilistic models to drive the simulation. However, one approach to dealing with this is to log all activity so tests can be replayed, a technique used by DiaSim [10]. This is not a total solution since it only supports investigation of replayed results and not replicating conditions for the purpose of a retest.

Scalability

Live test environments offer the most scalability in terms of time because test-users can occupy these spaces for days or weeks at a time, for example in the Aware Home or Ubiquitous Home. Agent or AI-driven simulations also perform well in this category, particularly when combined with automatic monitoring. However, few tools currently offer this combination. UbiREAL [12] provides the closest example, however a lack of generality combined with over-specification of test-cases, limits the extent of testing at run-time, particularly for uncovering unanticipated problems.

Spontaneous/Unanticipated Situations

Live environments again perform best in this category, primarily because the complexity of the human condition and spontaneous action cannot currently be truly simulated. However, models which simulate key aspects of human behaviour can provide some of the dynamism of human behaviour, for example the models in AmISim [9]. Simulation or prototyping tools driven by real users also provide some opportunity for unanticipated situations to arise, particularly if the test-user is a target end-user or at least is independent of the design process. DiaSim is not listed as featuring spontaneous user activity because the details available on its user model are sparse. UbiREAL is also not listed as supporting spontaneous user activity because it only allows a tester to defined static procedural routes for a simulated bot. SituVis [7] is listed as partially supporting discovery of unanticipated situations, because although SituVis does not support run-time testing, it provides an opportunity to uncover unexpected situational conflicts, which might otherwise not be foreseen.

Visual Monitoring

Most of the selected simulation and prototyping tools provide visualisations of the deployment environment. These allow the designer to visually monitor the effect of the ubicomp system in the physical environment. The exceptions are Paper Prototypes, Context Toolkit and VisualRDK [15], which all have in common that their prototypes run in live physical buildings.

Live environments can achieve visual monitoring by using cameras to record activity in the environment. The disadvantage of this is the significant man hours that must be invested in order to process the recordings and extract meaningful data.

SituVis is listed as partially providing visual monitoring for testing purposes because it provides intuitive views of the relationships and potential conflicts between situations.

Automatic Monitoring

Less has been achieved in terms of supporting designers with tools that automatically monitor ubicomp system behaviour. Of the surveyed tools, UbiREAL has made a notable contribution by enabling designers to define a system specification and check the execution of this logic in a simulated environment. VisualRDK makes a notable contribution by enabling developers to debug specially compiled localised versions of pervasive computing prototypes.

DiaSim and AmISim, both more recent work, state that their ambitions also lie in this area, however neither have produced publications with evidence of significant advances in this area yet.

Spatio-Temporal Relationship

Live environments provide the highest fidelity spatio-temporal relationship. Three dimensional simulators are also listed as maintaining the fidelity of the spatio-temporal relationship. Two dimensional simulators are listed as partially maintaining this relationship because they do not provide a full spatial model of the physical environment. Paper prototypes are listed as partially maintaining this relationship because although the fidelity of the physical world exists, the digital or computer temporal relationships are not authentic.

G.1.4 Evaluation

Technical Effectiveness

UbiREAL provided a significant contribution in this subcategory by enabling designers to define a formal service specification which could in turn be tested using a simulated environment for correctness. DiaSim is also making progress in this category with its parameterized approach to system specification, which in the longer term is expected to support debugging for ubiquitous computing systems. The researchers behind AmISim aim to provide forensic analysis as a method of

testing, debugging and analysing ubiquitous computing systems, however it appears that this remains part of their future work.

Situational Appropriateness

Live test-beds provide researchers with the opportunity to perform relatively long-term testing and evaluation of ubicomp system. The close approximation of these test-beds to real living conditions provides the opportunity for test-users to uncover unintended consequences of system behaviour. These conditions also provide the opportunity to uncover unusual or outlier situations that arise infrequently. The strength of this is the deep understanding and learning that is gained about these environments. However, the level of investment required for these test-beds is prohibitive to using them for mass development. Designers need tools which can evaluate the appropriateness of system behaviour using a more affordable approach.

Traceable Causal Factors

DiaSim comes closest to providing traceability of events leading to situations of interest. This is achieved through recorded log files, which can be replayed or manually examined, in order to identify the sequences of events leading to a specific situations. The limitation of DiaSim is that the tool does not provide automatic monitoring. The designer must visually monitor the simulated environment in order to identify problems which is unlikely to be as thorough as an automatic monitoring approach.

Appendix H

XSD Schemas

This appendix lists the XML schema definitions (XSD) for the Spatial Model, State Model initialisation information, test configuration file and simulator messages.

H.1 Spatial Model

This schema realises the implementation of the Spatial Model introduced in Chapter 4. Models defined using this schema are used to initialise the State Model, which is managed by the Monitoring Engine, discussed in Chapter 5.

Listing H.1: XSD for Spatial Model.

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
3   elementFormDefault="qualified">
4   <xs:element name="esrm">
5     <xs:complexType>
6       <xs:sequence>
7         <xs:element minOccurs="1" maxOccurs="1" ref="building"/>
8       </xs:sequence>
9     </xs:complexType>
10  </xs:element>
```

```

11 <xs:element name="building">
12   <xs:complexType>
13     <xs:sequence>
14       <xs:element minOccurs="0" maxOccurs="unbounded" ref="vertical-space"/>
15       <xs:element minOccurs="1" maxOccurs="unbounded" ref="floor"/>
16     </xs:sequence>
17     <xs:attribute name="id" use="required" type="xs:NCName"/>
18     <xs:attribute name="type" type="xs:NCName"/>
19   </xs:complexType>
20 </xs:element>
21 <xs:element name="vertical-space">
22   <xs:complexType>
23     <xs:sequence>
24       <xs:element minOccurs="0" maxOccurs="unbounded" ref="area"/>
25       <xs:element minOccurs="0" maxOccurs="unbounded" ref="entity"/>
26     </xs:sequence>
27     <xs:attribute name="id" use="required" type="xs:NCName"/>
28     <xs:attribute name="purpose" type="xs:NCName"/>
29   </xs:complexType>
30 </xs:element>
31 <xs:element name="floor">
32   <xs:complexType>
33     <xs:sequence>
34       <xs:element minOccurs="0" maxOccurs="unbounded" ref="entity"/>
35       <xs:element minOccurs="0" maxOccurs="unbounded" ref="room"/>
36       <xs:element minOccurs="0" maxOccurs="unbounded" ref="space"/>
37     </xs:sequence>
38     <xs:attribute name="id" use="required" type="xs:integer"/>
39     <xs:attribute name="type" type="xs:NCName"/>
40   </xs:complexType>
41 </xs:element>
42 <xs:element name="space">
43   <xs:complexType>
44     <xs:sequence>
45       <xs:element ref="entity"/>
46       <xs:element maxOccurs="unbounded" ref="room"/>
47     </xs:sequence>

```

```

48     <xs:attribute name="id" use="required" type="xs:NCName"/>
49     <xs:attribute name="type" type="xs:NCName"/>
50   </xs:complexType>
51 </xs:element>
52 <xs:element name="area">
53   <xs:complexType>
54     <xs:attribute name="id" use="required" type="xs:NMTOKEN"/>
55     <xs:attribute name="type" type="xs:NCName"/>
56   </xs:complexType>
57 </xs:element>
58 <xs:element name="door">
59   <xs:complexType>
60     <xs:attribute name="entry" type="xs:NCName"/>
61     <xs:attribute name="exit" type="xs:NCName"/>
62     <xs:attribute name="id" use="required" type="xs:NCName"/>
63     <xs:attribute name="initial-state" use="required" type="xs:NCName"/>
64     <xs:attribute name="type" type="xs:NCName"/>
65   </xs:complexType>
66 </xs:element>
67 <xs:element name="room">
68   <xs:complexType>
69     <xs:sequence>
70       <xs:element minOccurs="0" maxOccurs="unbounded" ref="entity"/>
71       <xs:element minOccurs="0" maxOccurs="unbounded" ref="area"/>
72     </xs:sequence>
73     <xs:attribute name="id" use="required" type="xs:NCName"/>
74     <xs:attribute name="type" type="xs:NCName"/>
75   </xs:complexType>
76 </xs:element>
77 <xs:element name="entity">
78   <xs:complexType>
79     <xs:attribute name="id" use="required" type="xs:NCName"/>
80     <xs:attribute name="initial-state" use="required" type="xs:NCName"/>
81     <xs:attribute name="mobile" type="xs:NCName"/>
82     <xs:attribute name="type" type="xs:NCName"/>
83   </xs:complexType>
84 </xs:element>

```

H.2 Test Initialisation Schema

This schema defines the elements of the initialisation file which can be used to describe the initial view of the deployment environment. Files defined using this schema are used to initialise the State Model, which is managed by the Monitoring Engine, as discussed in Chapter 5. The Spatial Model schema includes zones, entities and doors, as a result it is only necessary for this model to provide information about users.

Listing H.2: XSD for Initialisation File for User Facts.

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
3   elementFormDefault="qualified">
4   <xs:element name="um">
5     <xs:complexType>
6       <xs:sequence>
7         <xs:element maxOccurs="unbounded" ref="user"/>
8       </xs:sequence>
9     </xs:complexType>
10  </xs:element>
11  <xs:element name="user">
12    <xs:complexType>
13      <xs:sequence>
14        <xs:element ref="id"/>
15        <xs:element ref="position"/>
16        <xs:element ref="office"/>
17        <xs:element ref="risk"/>
18        <xs:element ref="type"/>
19      </xs:sequence>
20    </xs:complexType>
```

```
21 </xs:element>
22 <xs:element name="id" type="xs:NCName"/>
23 <xs:element name="position" type="xs:NCName"/>
24 <xs:element name="office" type="xs:NCName"/>
25 <xs:element name="risk" type="xs:NCName"/>
26 <xs:element name="type" type="xs:NCName"/>
27 </xs:schema>
```

H.3 Message Schema

This schema defines the information exchange format for sensed context messages and state updates, used in the Toolset implementation as discussed in Chapter 5.

Listing H.3: XSD for Message Exchange via Update Router.

```
1 <?xml version="1.0" encoding="UTF-8" ?>
2 <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
3   <xs:element name="entityID">
4     <xs:complexType mixed="true" />
5   </xs:element>
6   <xs:element name="entityType">
7     <xs:complexType mixed="true" />
8   </xs:element>
9   <xs:element name="state">
10    <xs:complexType mixed="true" />
11  </xs:element>
12  <xs:element name="zoneID">
13    <xs:complexType mixed="true" />
14  </xs:element>
15  <xs:element name="yaw">
16    <xs:complexType mixed="true" />
17  </xs:element>
18  <xs:element name="coords">
19    <xs:complexType>
```

```

20     <xs:sequence>
21         <xs:element ref="x" />
22         <xs:element ref="y" />
23         <xs:element ref="z" />
24     </xs:sequence>
25 </xs:complexType>
26 </xs:element>
27 <xs:element name="msg">
28     <xs:complexType>
29         <xs:sequence>
30             <xs:element ref="entityType" />
31             <xs:element ref="entityID" />
32             <xs:element ref="state" />
33             <xs:element ref="userID" />
34             <xs:element ref="coords" />
35             <xs:element ref="zoneID" />
36             <xs:element ref="yaw" />
37             <xs:element ref="time" />
38         </xs:sequence>
39     </xs:complexType>
40 </xs:element>
41 <xs:element name="userID">
42     <xs:complexType mixed="true" />
43 </xs:element>
44 <xs:element name="time">
45     <xs:complexType mixed="true" />
46 </xs:element>
47 <xs:element name="x">
48     <xs:complexType mixed="true" />
49 </xs:element>
50 <xs:element name="y">
51     <xs:complexType mixed="true" />
52 </xs:element>
53 <xs:element name="z">
54     <xs:complexType mixed="true" />
55 </xs:element>
56 </xs:schema>

```

H.4 Test Configuration

This schema defines the elements of the configuration file used to set up a test simulation.

Listing H.4: XSD for Test Configuration File.

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
3   elementFormDefault="qualified">
4   <xs:element name="experiment">
5     <xs:complexType>
6       <xs:sequence>
7         <xs:element ref="meta"/>
8         <xs:element ref="database"/>
9         <xs:element ref="simulator"/>
10        <xs:element ref="service-settings"/>
11        <xs:element ref="subscriptions"/>
12      </xs:sequence>
13    </xs:complexType>
14  </xs:element>
15  <xs:element name="meta">
16    <xs:complexType>
17      <xs:sequence>
18        <xs:element ref="exp"/>
19        <xs:element ref="exp_id"/>
20        <xs:element ref="service_id"/>
21        <xs:element ref="author"/>
22        <xs:element ref="date-created"/>
23        <xs:element ref="date-edited"/>
24      </xs:sequence>
25    </xs:complexType>
26  </xs:element>
27  <xs:element name="exp" type="xs:string"/>
28  <xs:element name="exp_id" type="xs:NCName"/>
29  <xs:element name="service_id" type="xs:NCName"/>
```

```

30 <xs:element name="author" type="xs:string"/>
31 <xs:element name="date-created" type="xs:string"/>
32 <xs:element name="date-edited" type="xs:string"/>
33 <xs:element name="database">
34   <xs:complexType>
35     <xs:sequence>
36       <xs:element ref="db_uri"/>
37       <xs:element ref="http_uri"/>
38       <xs:element ref="driver"/>
39       <xs:element ref="model_directory"/>
40       <xs:element ref="situation_model"/>
41       <xs:element ref="alert_report"/>
42       <xs:element ref="spatial_model"/>
43       <xs:element ref="initial_model"/>
44     </xs:sequence>
45   </xs:complexType>
46 </xs:element>
47 <xs:element name="db_uri" type="xs:anyURI"/>
48 <xs:element name="http_uri" type="xs:anyURI"/>
49 <xs:element name="driver" type="xs:NCName"/>
50 <xs:element name="model_directory" type="xs:string"/>
51 <xs:element name="situation_model" type="xs:NCName"/>
52 <xs:element name="alert_report" type="xs:NCName"/>
53 <xs:element name="spatial_model" type="xs:NCName"/>
54 <xs:element name="initial_model" type="xs:NCName"/>
55 <xs:element name="simulator">
56   <xs:complexType>
57     <xs:sequence>
58       <xs:element ref="sim_host"/>
59       <xs:element ref="sim_inbound_port"/>
60       <xs:element ref="sim_outbound_port"/>
61       <xs:element ref="exec"/>
62       <xs:element ref="args"/>
63       <xs:element ref="bsp"/>
64     </xs:sequence>
65   </xs:complexType>
66 </xs:element>

```

```
67 <xs:element name="sim_host" type="xs:NMTOKEN"/>
68 <xs:element name="sim_inbound_port" type="xs:integer"/>
69 <xs:element name="sim_outbound_port" type="xs:integer"/>
70 <xs:element name="exec" type="xs:string"/>
71 <xs:element name="args" type="xs:string"/>
72 <xs:element name="bsp" type="xs:NCName"/>
73 <xs:element name="subscriptions">
74   <xs:complexType>
75     <xs:sequence>
76       <xs:element maxOccurs="unbounded" ref="datasource"/>
77     </xs:sequence>
78   </xs:complexType>
79 </xs:element>
80 <xs:element name="datasource" type="xs:NCName"/>
81 </xs:schema>
```

Appendix I

Access Control Case Study

This appendix presents simulation results, i.e. charted Alert Reports, for the access control case study in Chapter 6.

I.1 Results

This section presents charted Alert Reports for each of the access control simulations. Figure I.1 summarises the simulation configurations for these results. Within this section, where data section appears irregular, this was due to a limitation in data quantity processing capabilities in Microsoft Excel spreadsheets. Charts that trace bot location are included and alerts are printed as overlays on these figures. Traces of device actuations are also included for each simulation.

		RFID Readers	Motion Sensors	Proximity Detectors
Simulation 1: RFID	Access Control System	External Doors: G29, G31, Coffee Room		
Simulation 2: RFID and Motion Sensors	Access Control System	External Doors: G29, G31, Coffee Room	G29, G30, G31, Coffee Room	
	Lighting System		G29, G30, G31, Coffee Room	
Simulation 3: RFID, Motion Sensors and Proximity Detectors	Access Control System	External Doors: G29, G31, Coffee Room	G29, G30, G31, Coffee Room	All Desk Areas: G29, G30, G31
	Lighting System		G29, G30, G31, Coffee Room	All Desk Areas: G29, G30, G31

		Doors	Lights
Simulation 1: RFID	Access Control System	External Doors: G29, G31, Coffee Room	
Simulation 2: RFID and Motion Sensors	Access Control System	External Doors: G29, G31, Coffee Room	
	Lighting System		Lights: G29, G30, G31, Coffee Room
Simulation 3: RFID, Motion Sensors and Proximity Detectors	Access Control System	External Doors: G29, G31, Coffee Room	
	Lighting System		Lights: G29, G30, G31, Coffee Room

Figure I.1: Simulation configurations for the Access Control Case Study.

I.1.1 Simulation 1: RFID

This section presents the results for the case study simulation that featured RFID access control. The section begins with a chart that summarises all detected situational instances and follows up with spatio-temporal traces for individual situation specifications.

Summary of Detected Situations

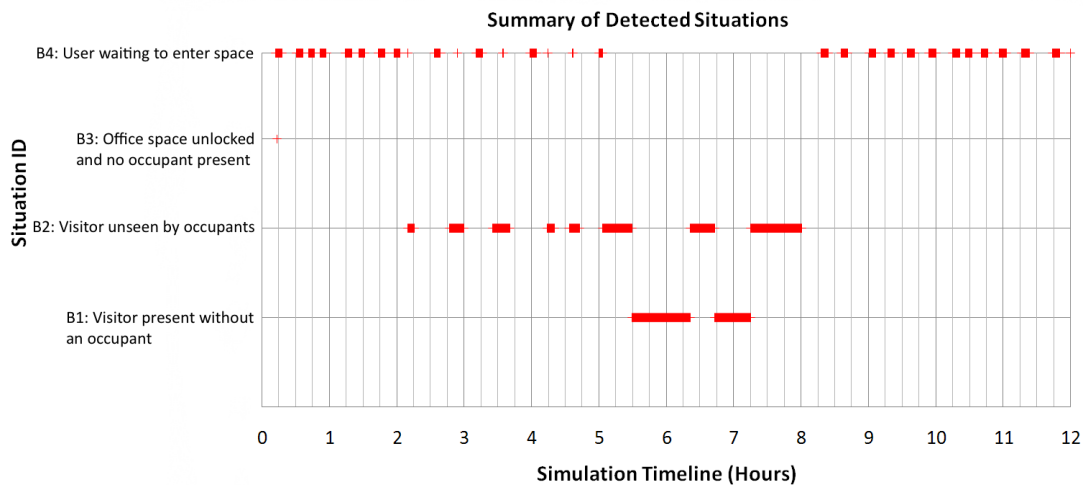


Figure I.2: Simulation 1 (RFID): Summary of detected situation instances.

Situation B1: Visitor present without an occupant.

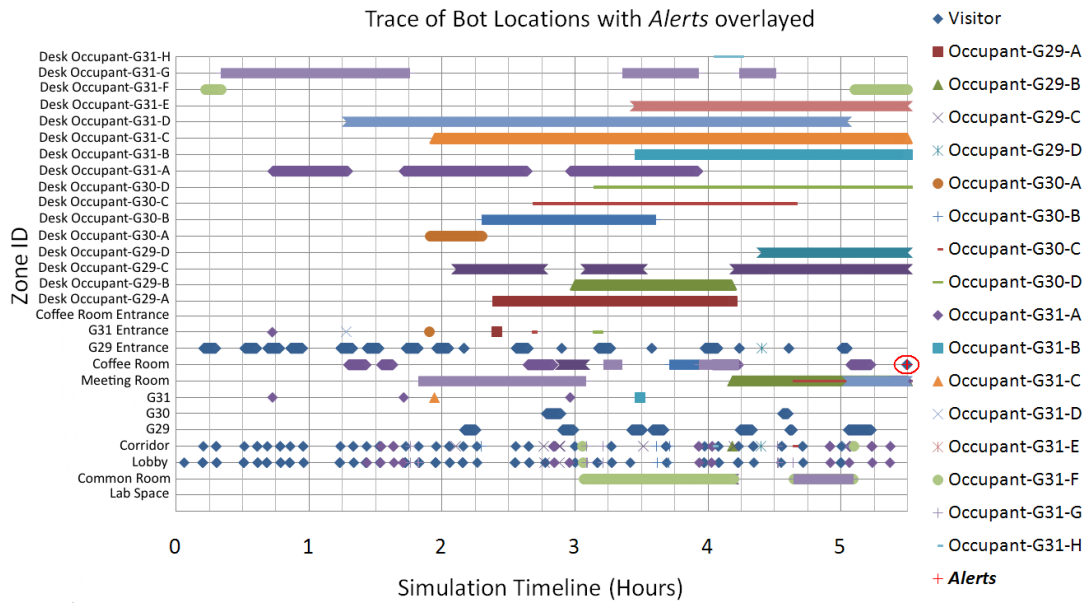


Figure I.3: Charted alerts for situation B1: *Visitor present without an occupant.*

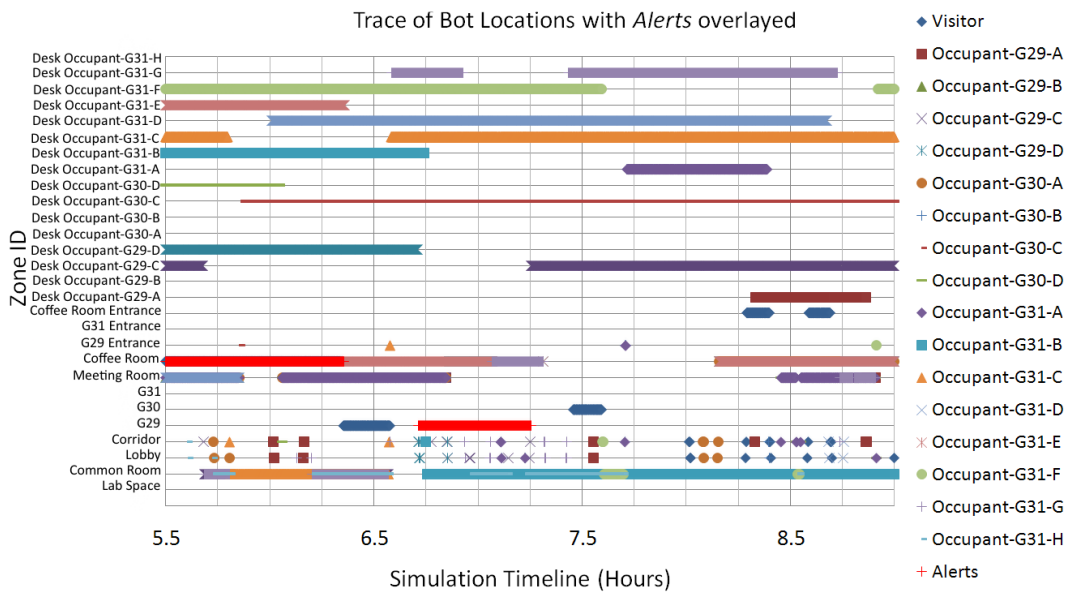


Figure I.4: Charted alerts for situation B1: *Visitor present without an occupant.*

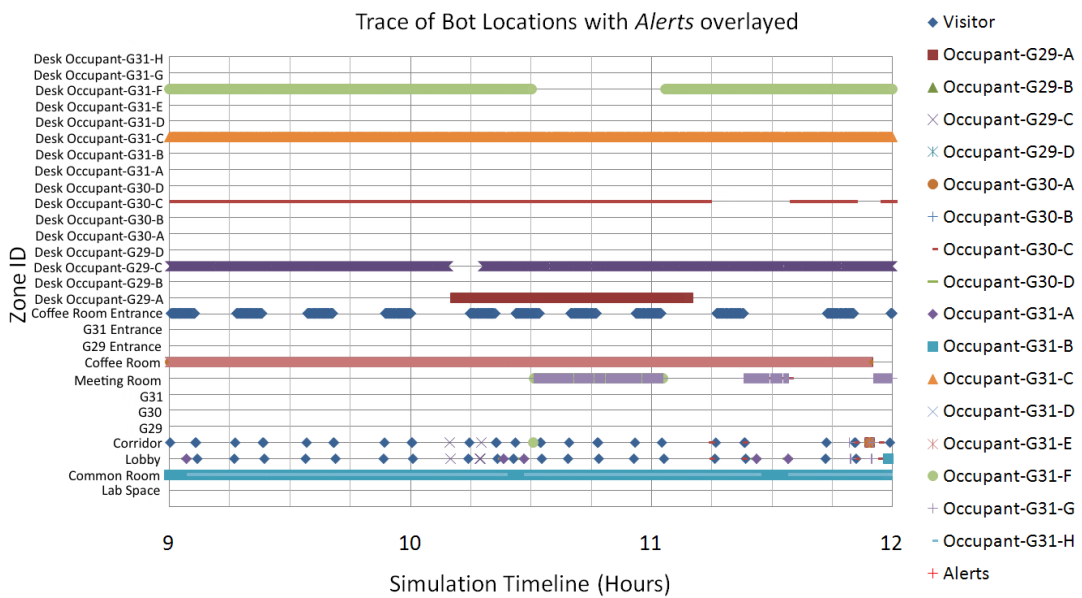


Figure I.5: Charted alerts for situation B1: *Visitor present without an occupant.*

Situation B2 Visitor unseen by occupants while occupant(s) present.

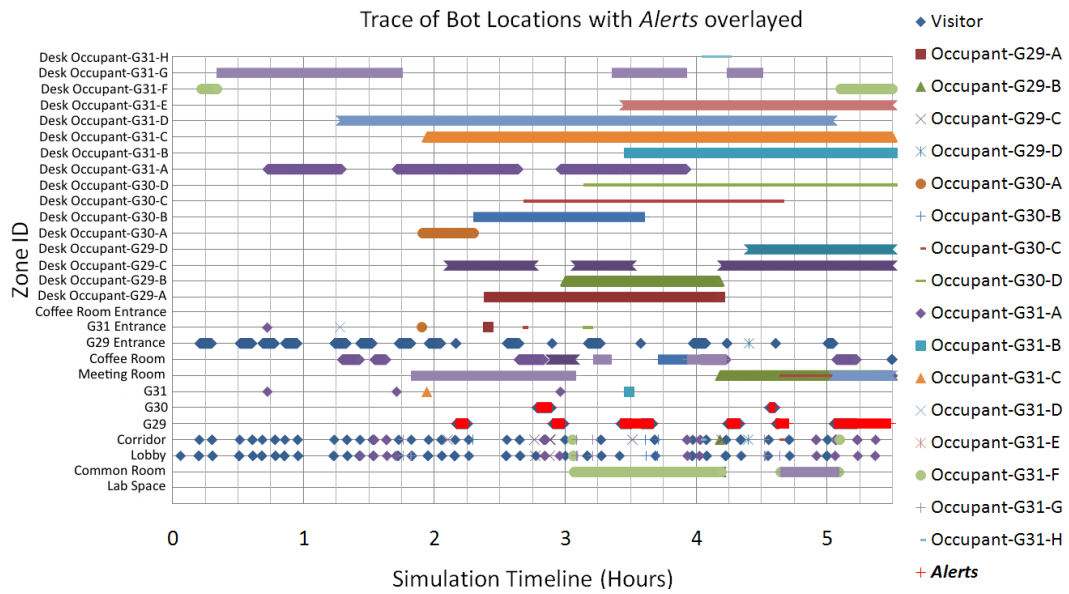


Figure I.6: Charted alerts for situation B2: *Visitor unseen by occupants while occupant(s) present.*

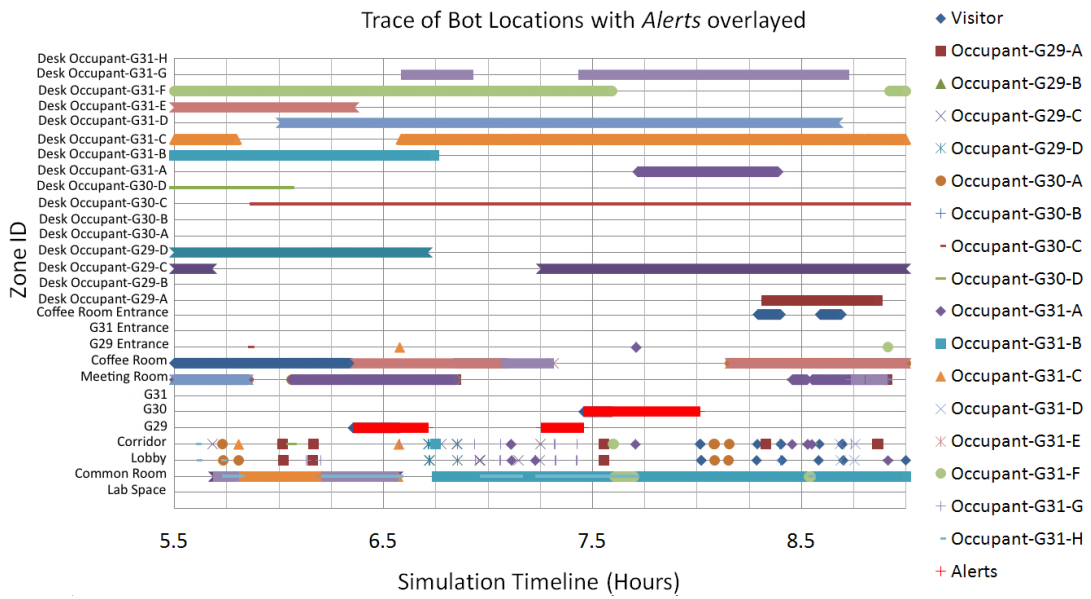


Figure I.7: Charted alerts for situation B2: *Visitor unseen by occupants while occupant(s) present.*

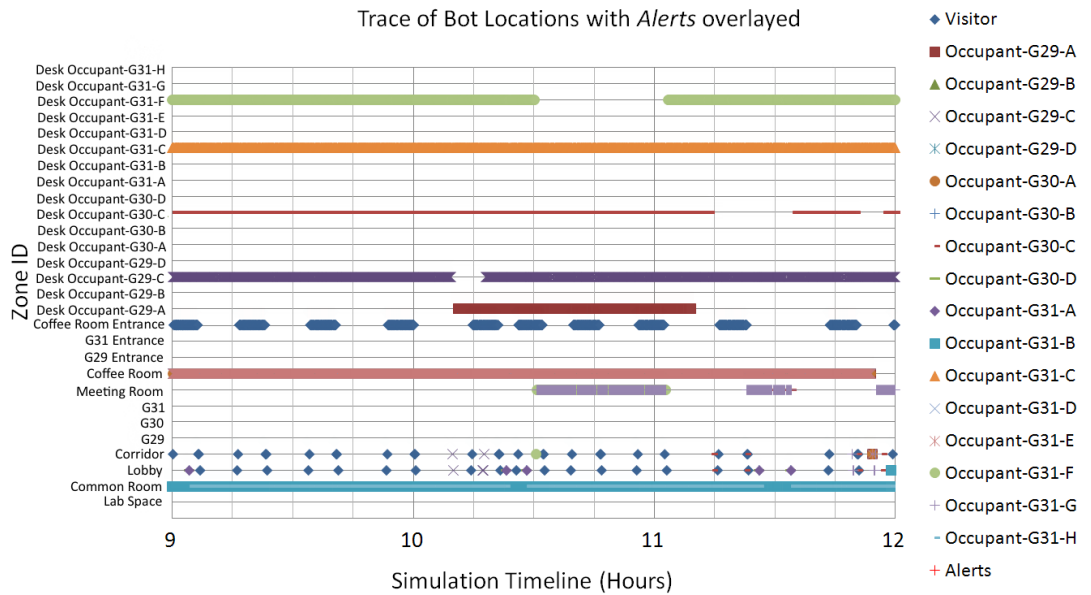


Figure I.8: Charted alerts for situation B2: *Visitor unseen by occupants while occupant(s) present.*

Situation B3: Office space unlocked and no occupant present.

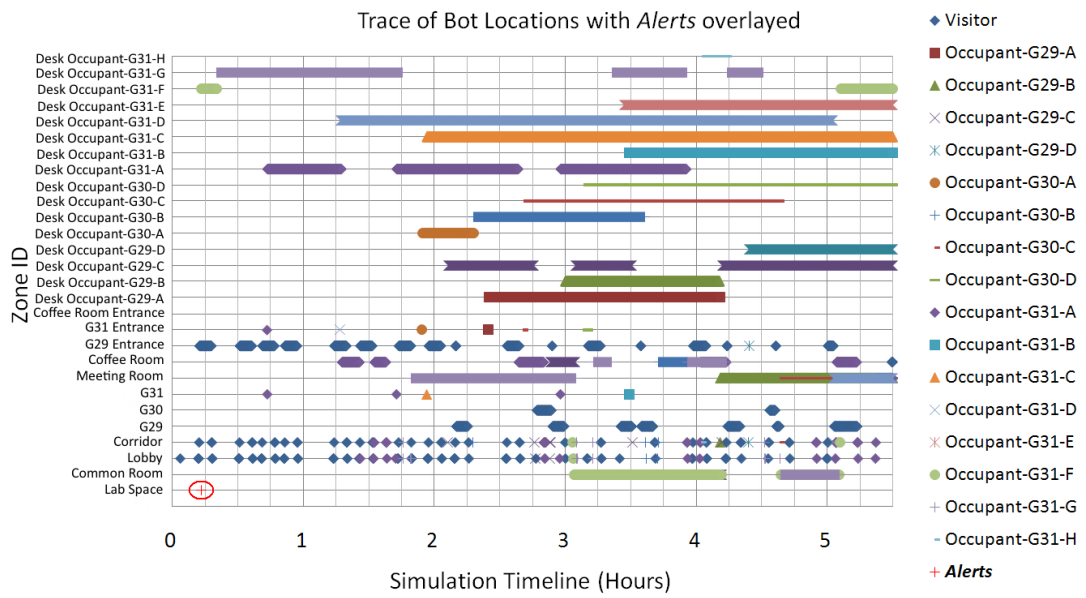


Figure I.9: Charted alerts for situation B3: *Office space unlocked and no occupant present.*

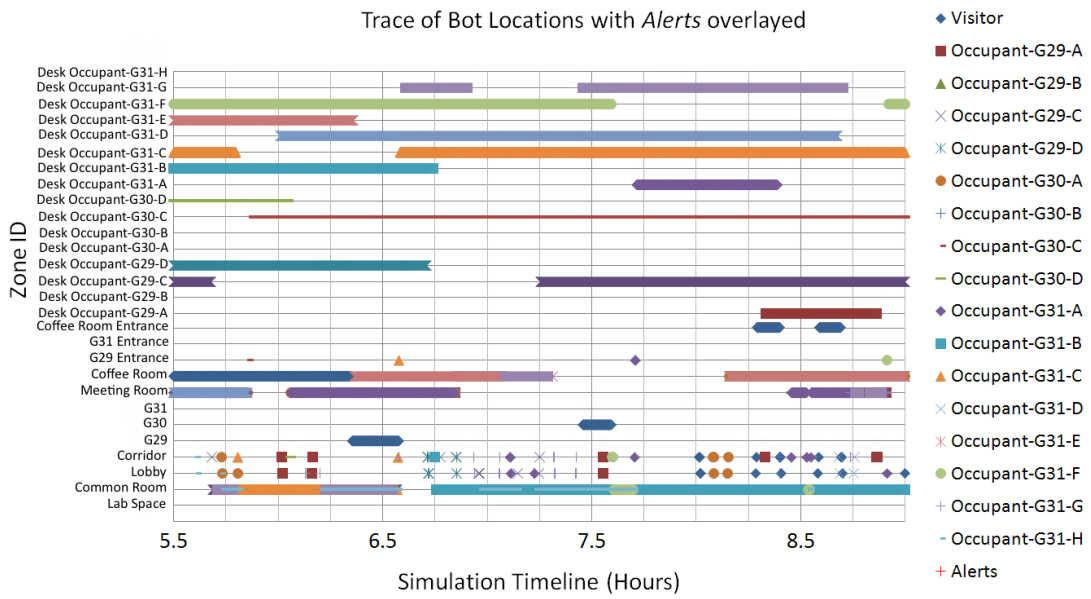


Figure I.10: Charted alerts for situation B3: *Office space unlocked and no occupant present.*

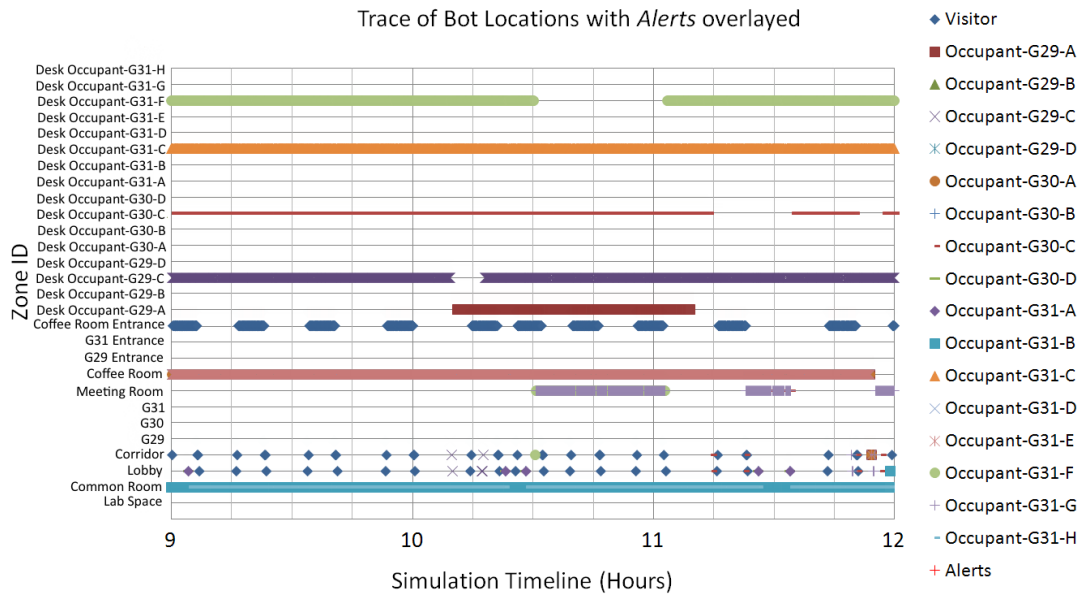


Figure I.11: Charted alerts for situation B3: *Office space unlocked and no occupant present.*

Situation B4: User waiting to enter space.

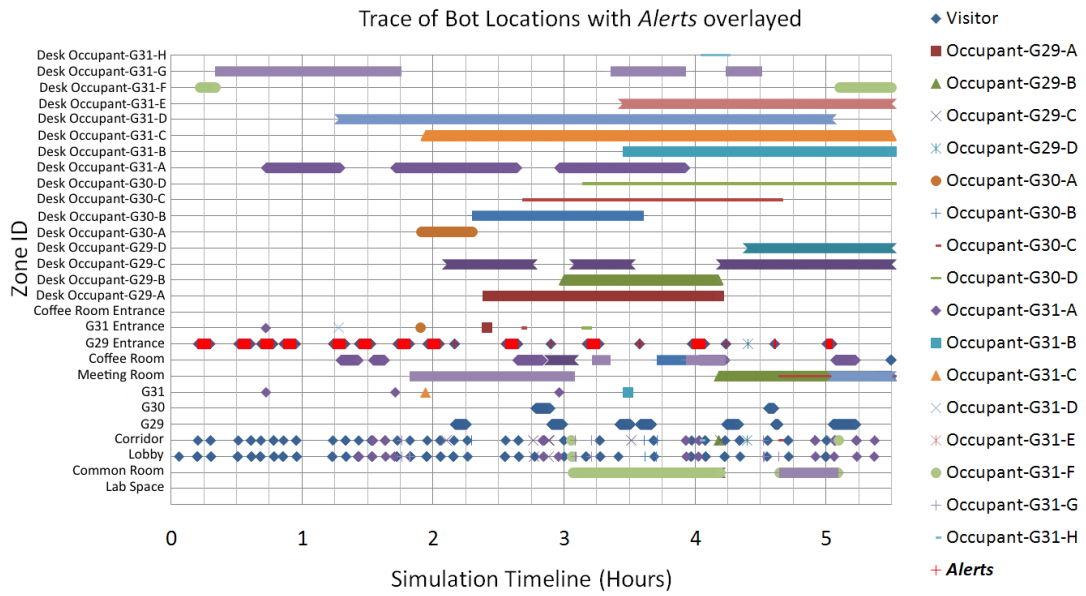


Figure I.12: Charted alerts for situation B4: *User waiting to enter space.*

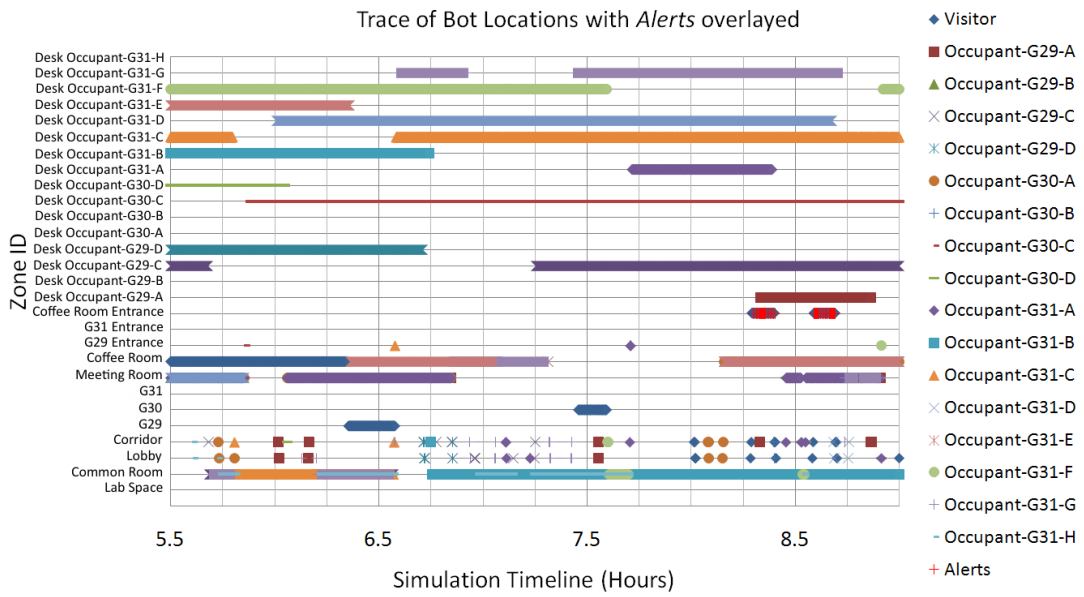


Figure I.13: Charted alerts for situation B4: *User waiting to enter space.*

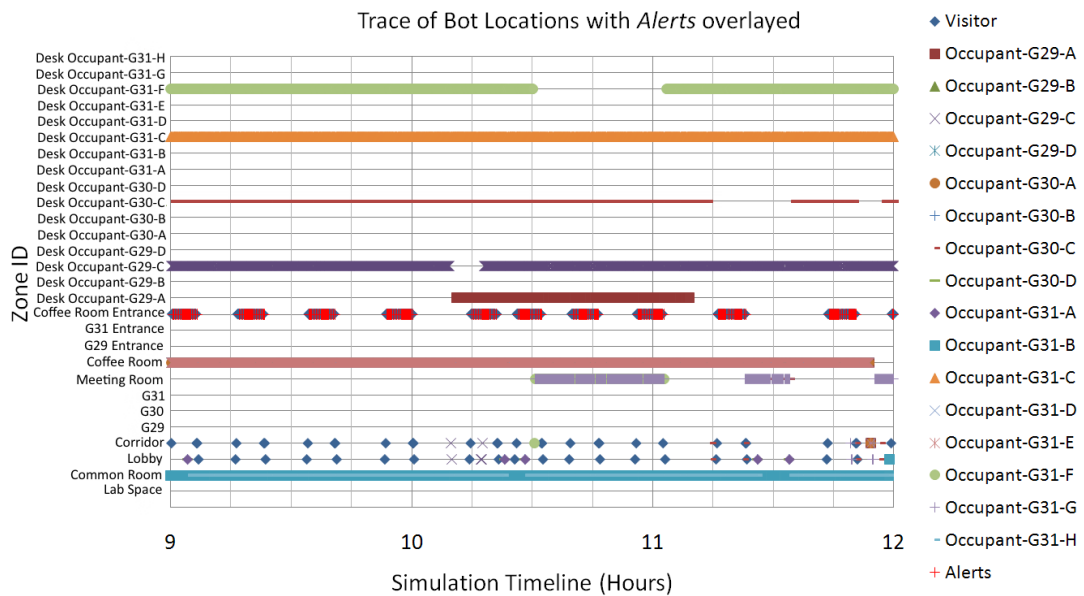


Figure I.14: Charted alerts for situation B4: *User waiting to enter space.*

Traces of Device Events

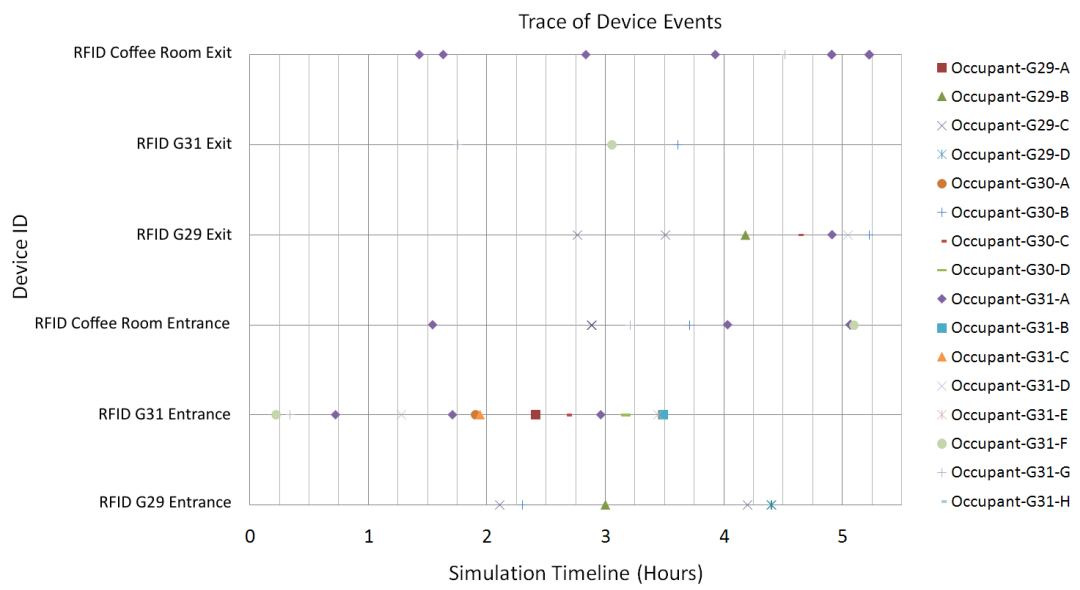


Figure I.15: Trace of device events.

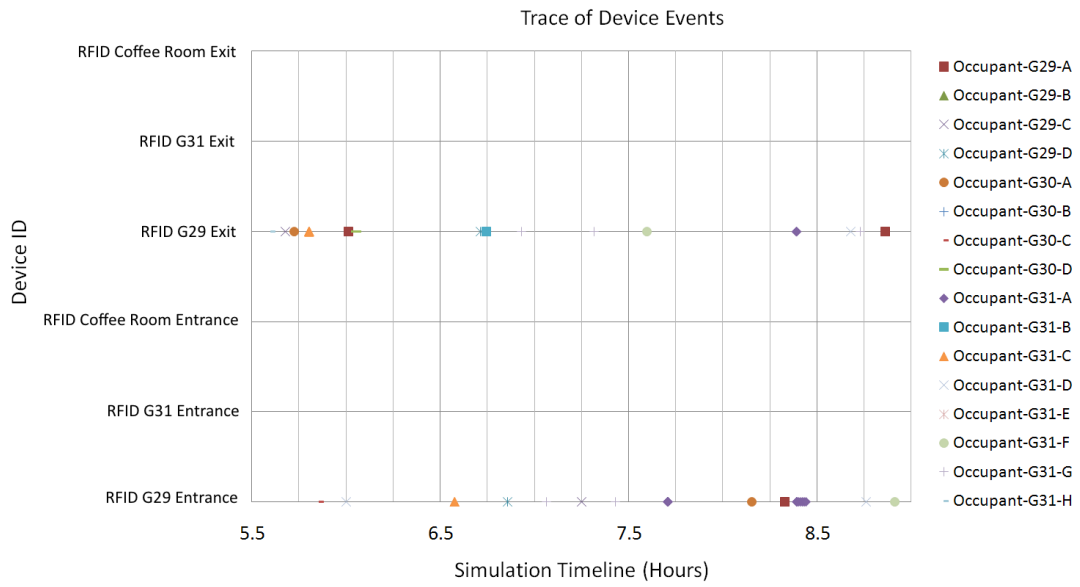


Figure I.16: Trace of device events.

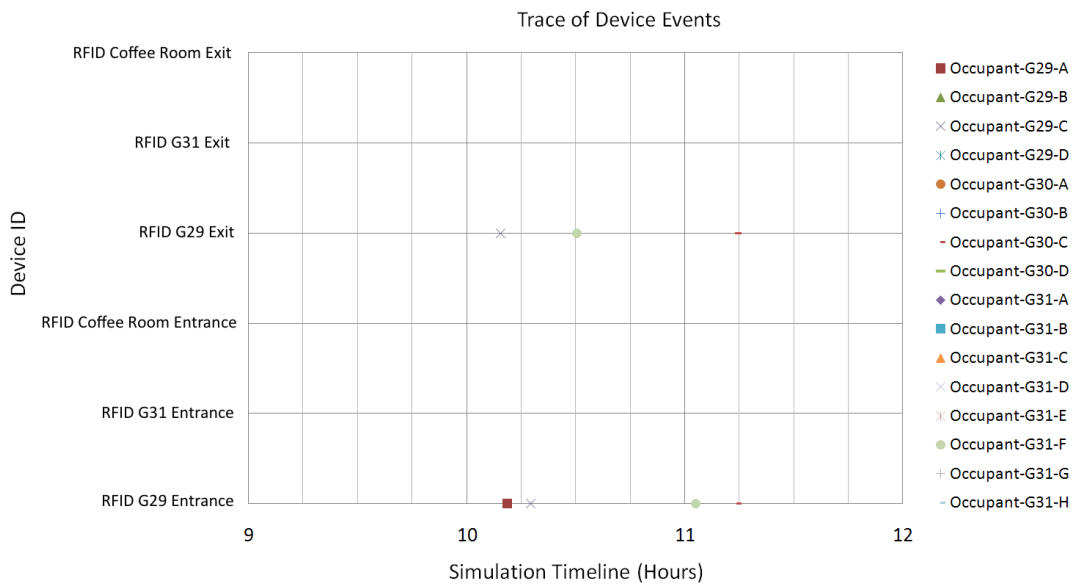


Figure I.17: Trace of device events.

I.1.2 Simulation 2: RFID and Motion Detection, with Lighting

This section presents the results for the case study simulation that featured RFID and motion sensor access control, alongside the lighting system from the first case study. The section begins with a chart that summarises all detected situational instances and follows up with spatio-temporal traces for individual situation specifications.

Summary of Detected Situations

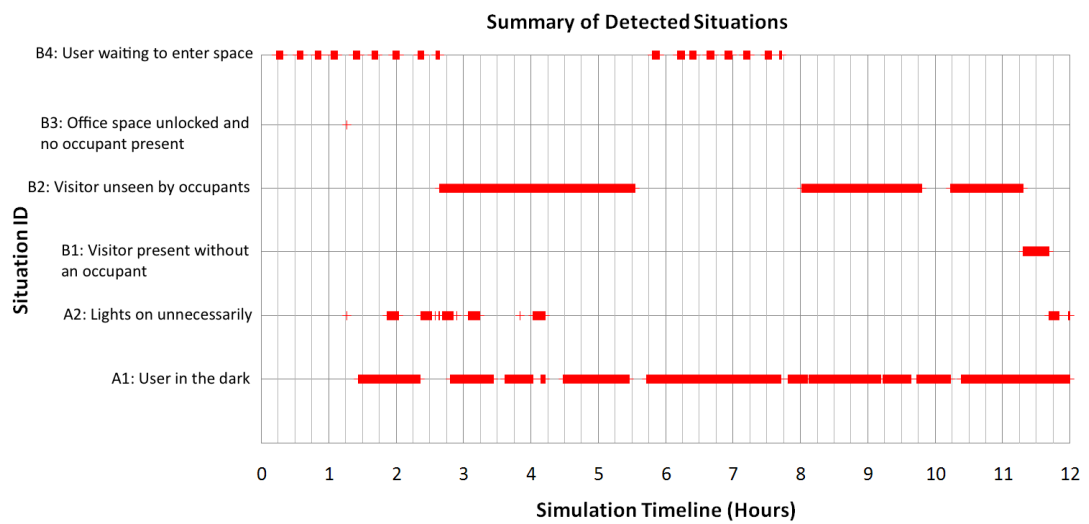


Figure I.18: Simulation 2 (RFID and Motion Detection): Summary of detected situation instances.

Situation B1: Visitor present without an occupant.

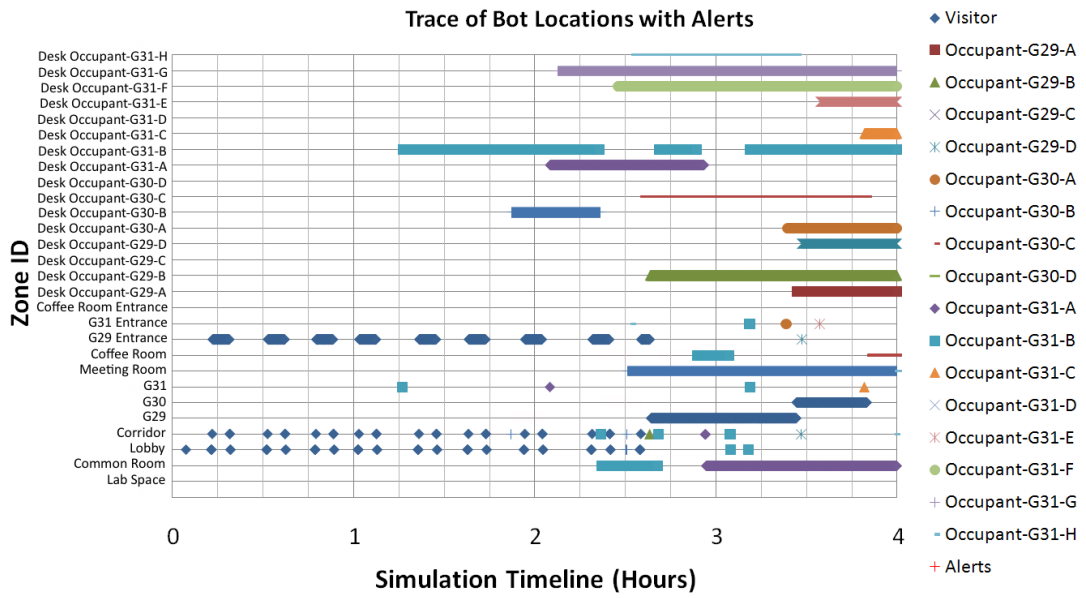


Figure I.19: Charted alerts for situation B1: *Visitor present without an occupant.*

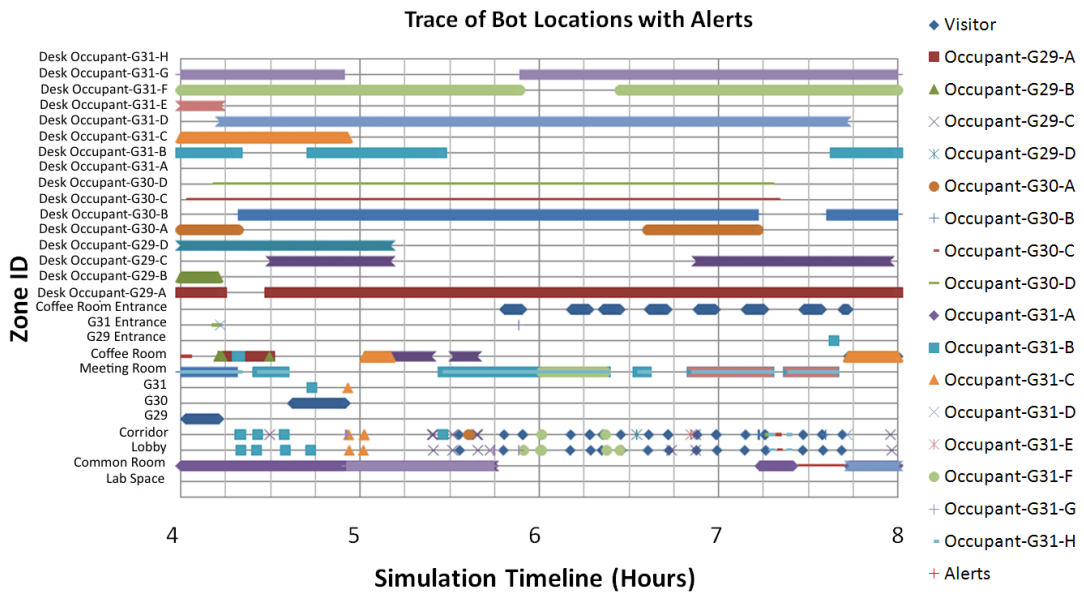


Figure I.20: Charted alerts for situation B1: *Visitor present without an occupant.*

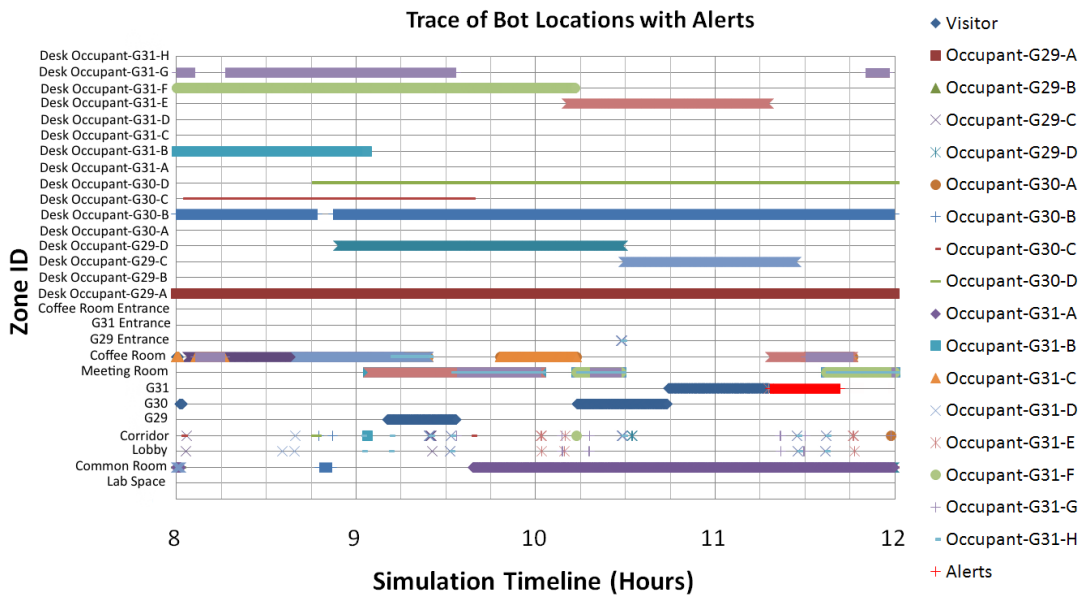


Figure I.21: Charted alerts for situation B1: *Visitor present without an occupant.*

Situation B2: Visitor unseen by occupants while occupant(s) present.

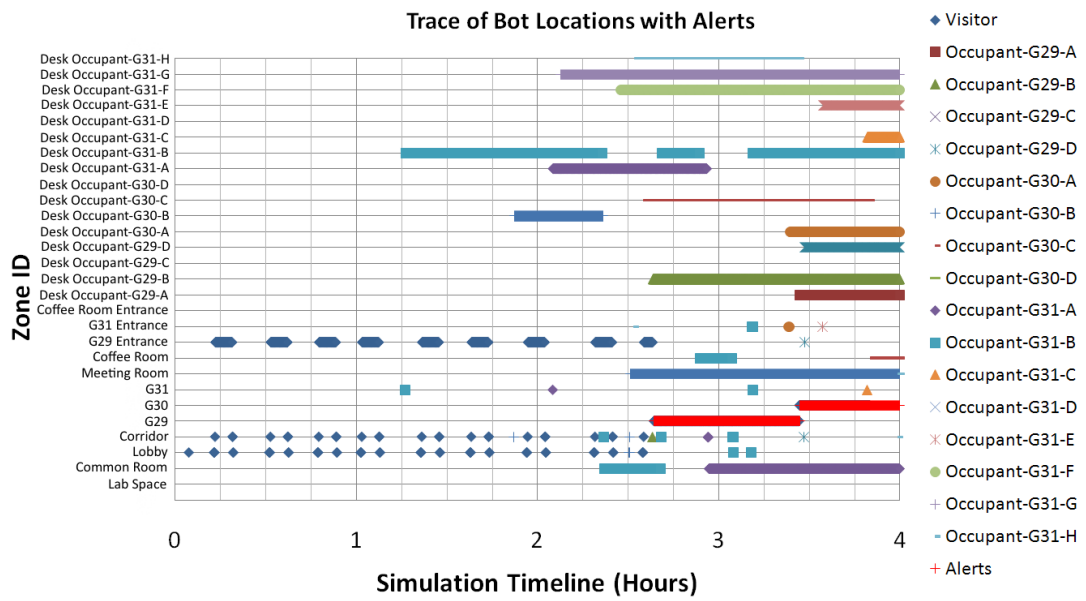


Figure I.22: Charted alerts for situation B2 : *Visitor unseen by occupants while occupant(s) present.*

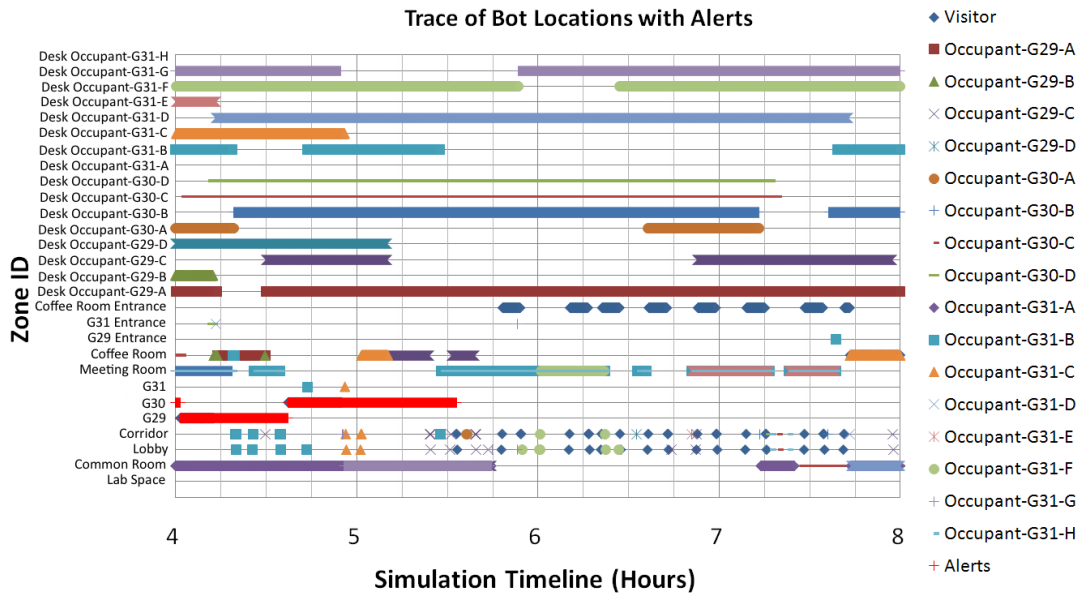


Figure I.23: Charted alerts for situation B2 : *Visitor unseen by occupants while occupant(s) present.*

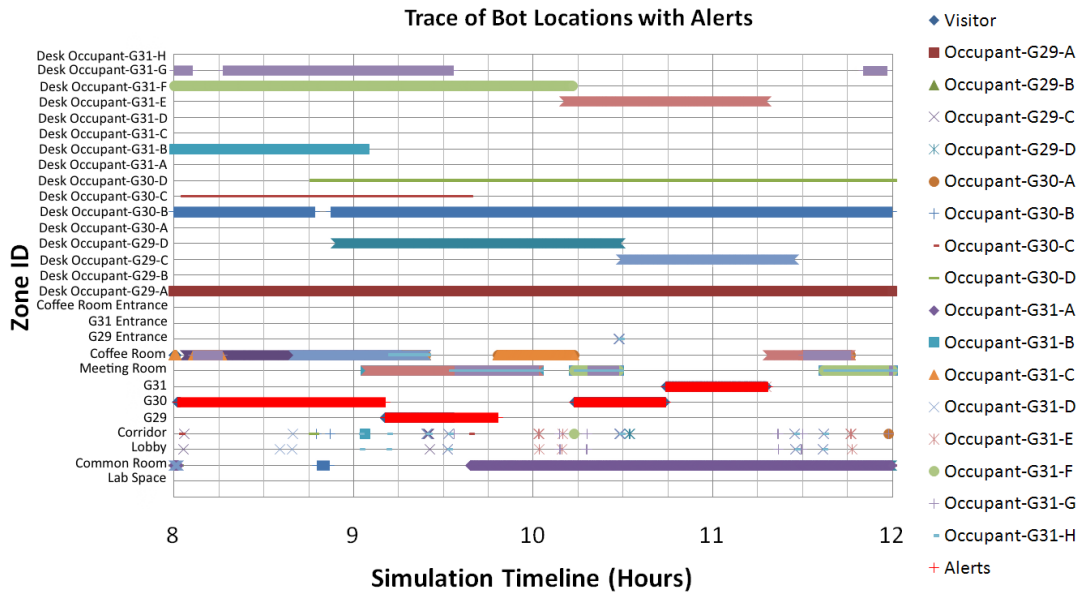


Figure I.24: Charted alerts for situation B2 : *Visitor unseen by occupants while occupant(s) present.*

Situation B3: Office space unlocked and no occupant present.

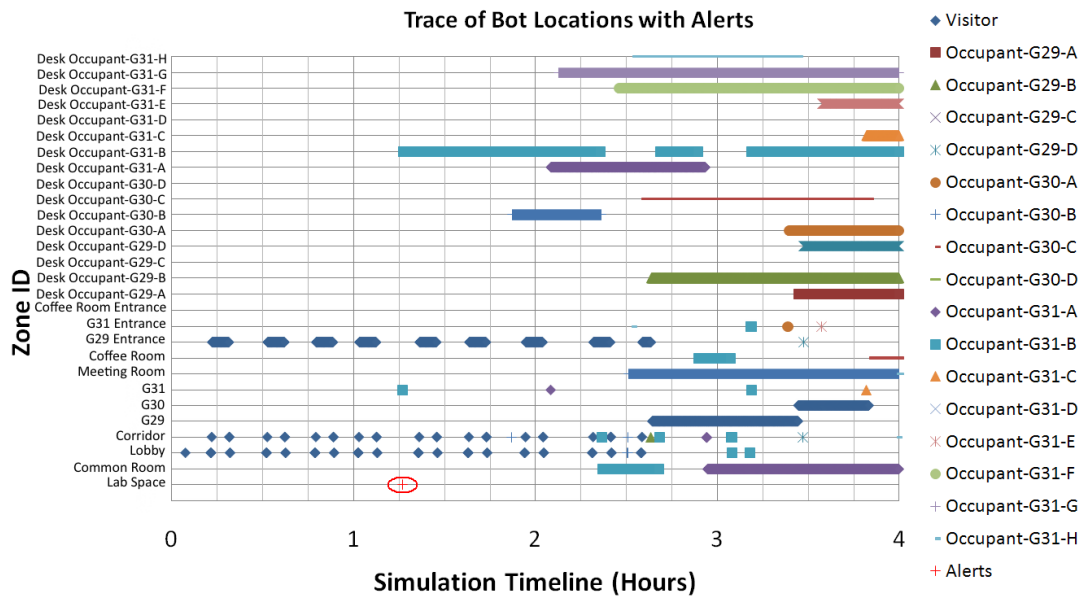


Figure I.25: Charted alerts for situation B3 : *Office space unlocked and no occupant present.*

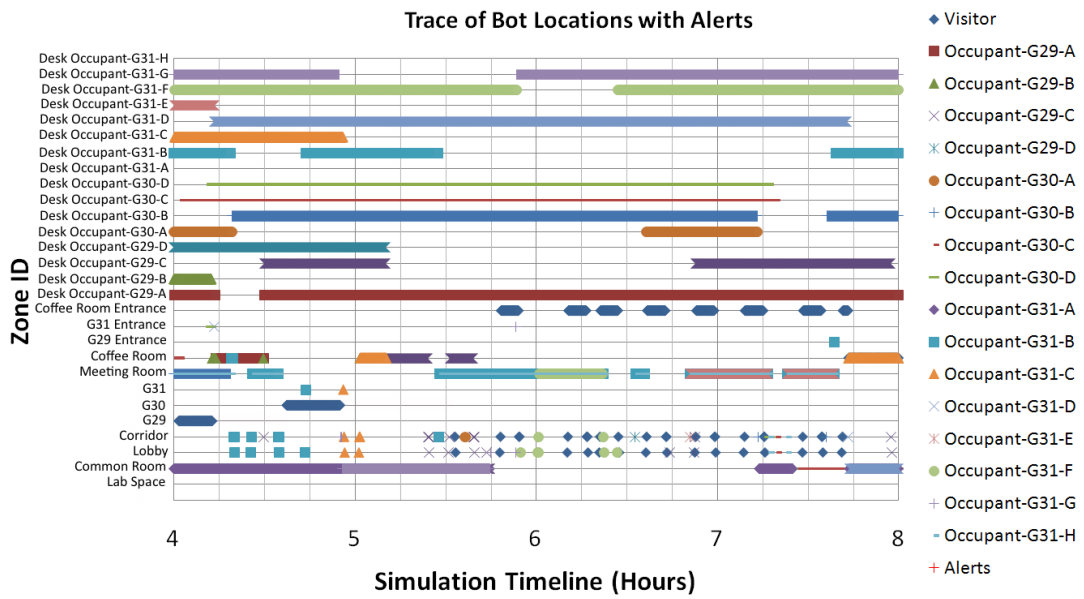


Figure I.26: Charted alerts for situation B3: *Office space unlocked and no occupant present.*

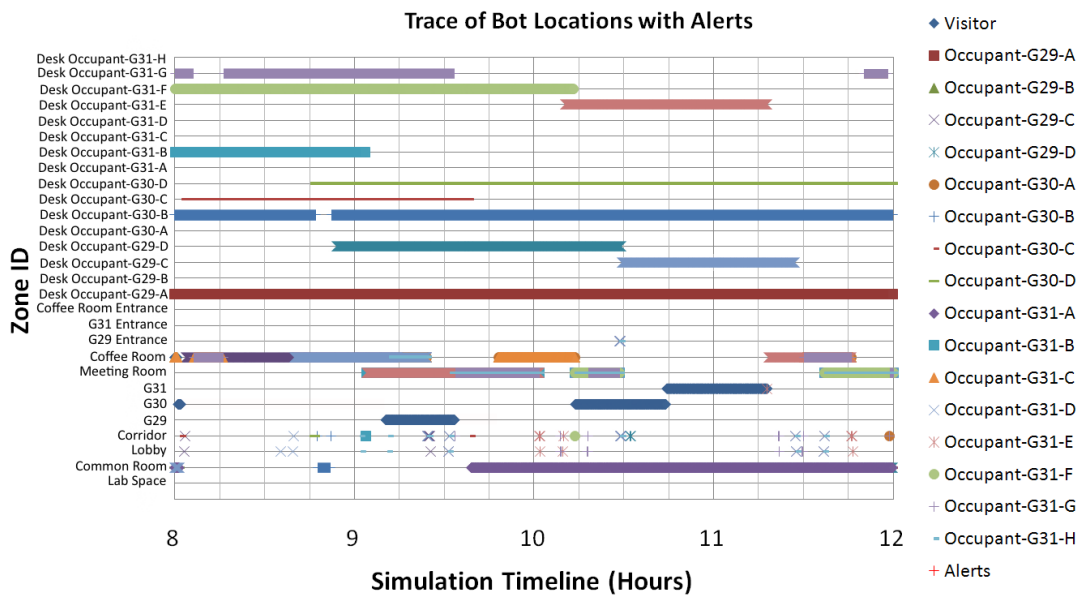


Figure I.27: Charted alerts for situation B3: *Office space unlocked and no occupant present.*

Situation B4: User waiting to enter space.

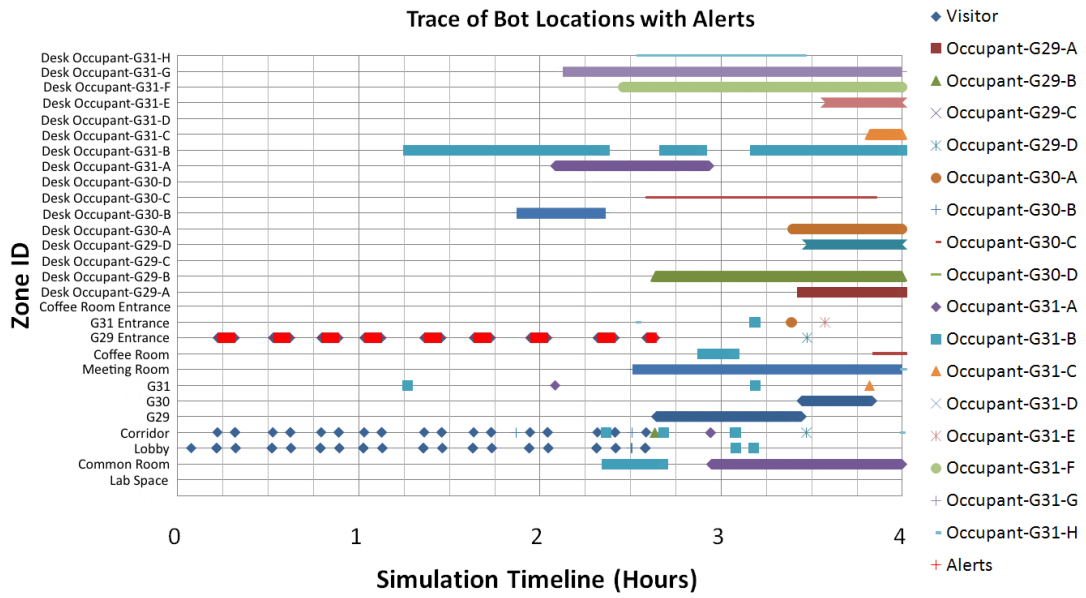


Figure I.28: Charted alerts for situation B4 : *User waiting to enter space.*

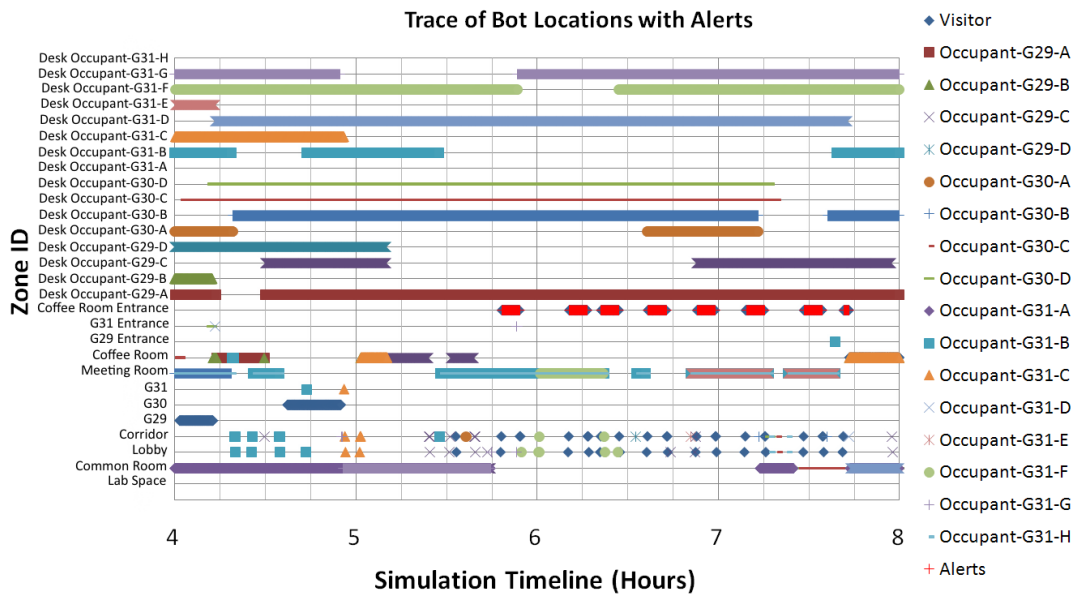


Figure I.29: Charted alerts for situation B4 : *User waiting to enter space.*

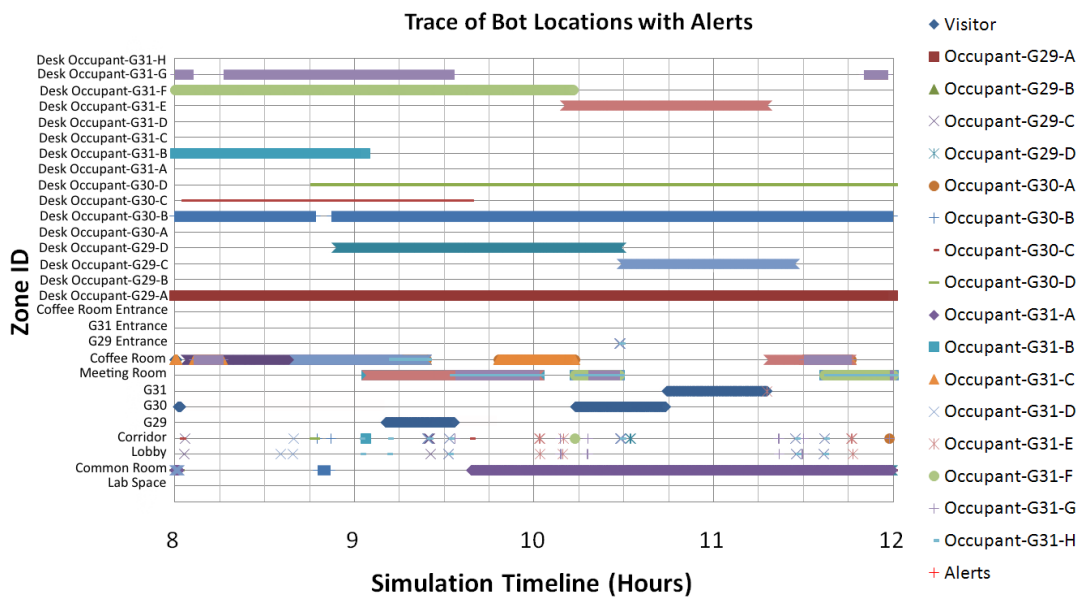


Figure I.30: Charted alerts for situation B4 : *User waiting to enter space.*

Situation A1: User in the dark.

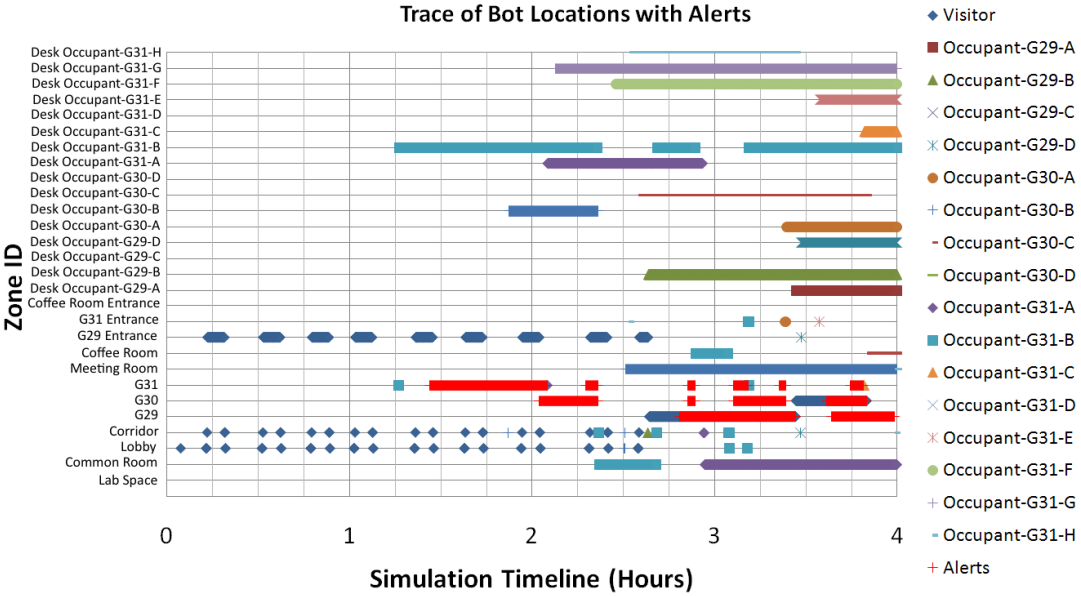


Figure I.31: Charted alerts for situation A1 : User in the dark.

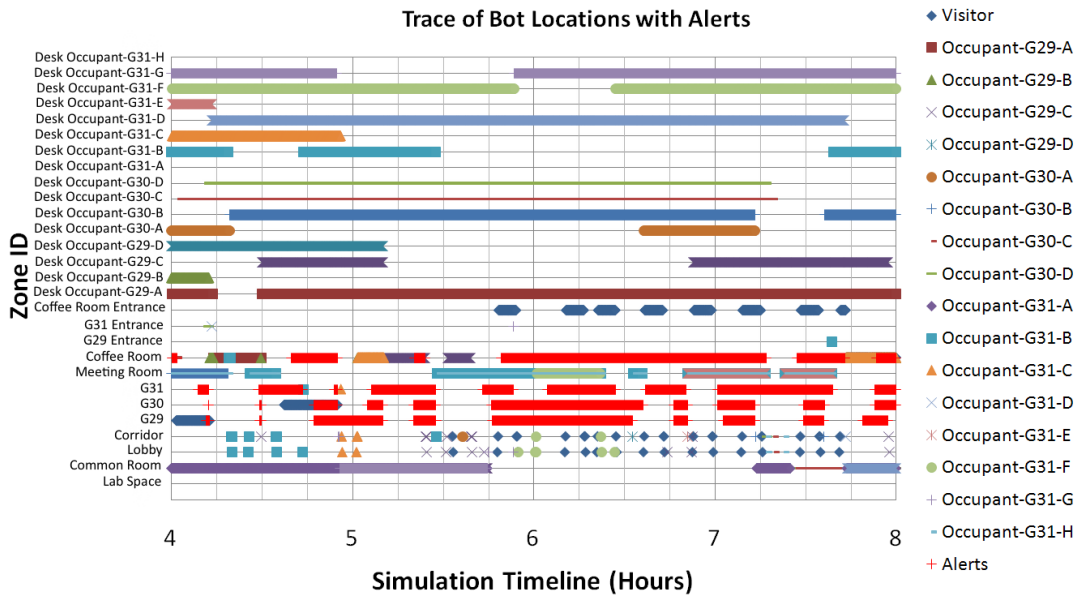


Figure I.32: Charted alerts for situation A1 : *User in the dark*.

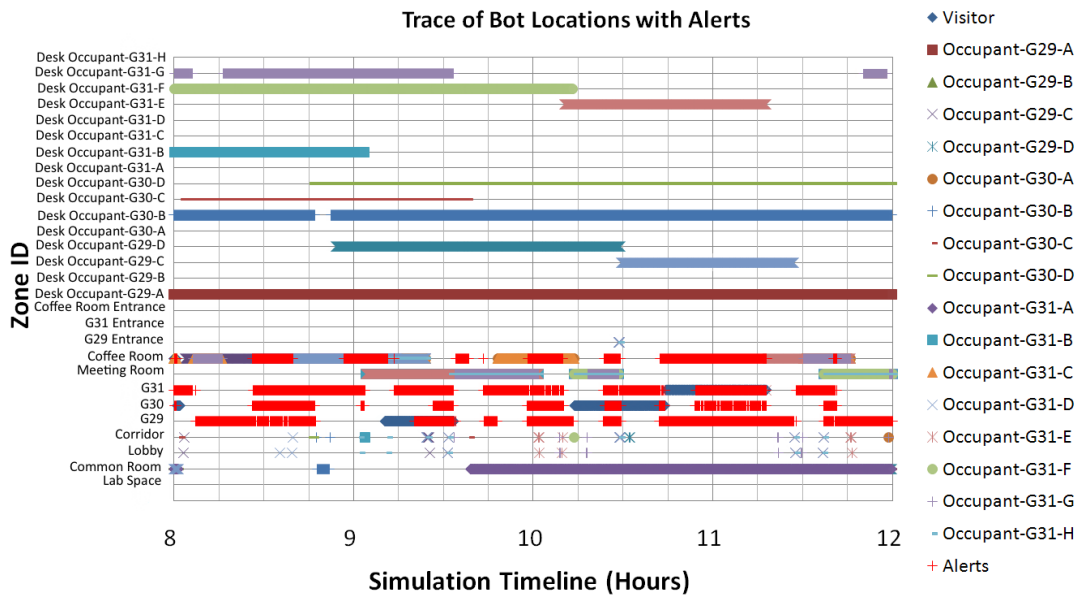


Figure I.33: Charted alerts for situation A1 : *User in the dark*.

Situation A2: Lights on unnecessarily

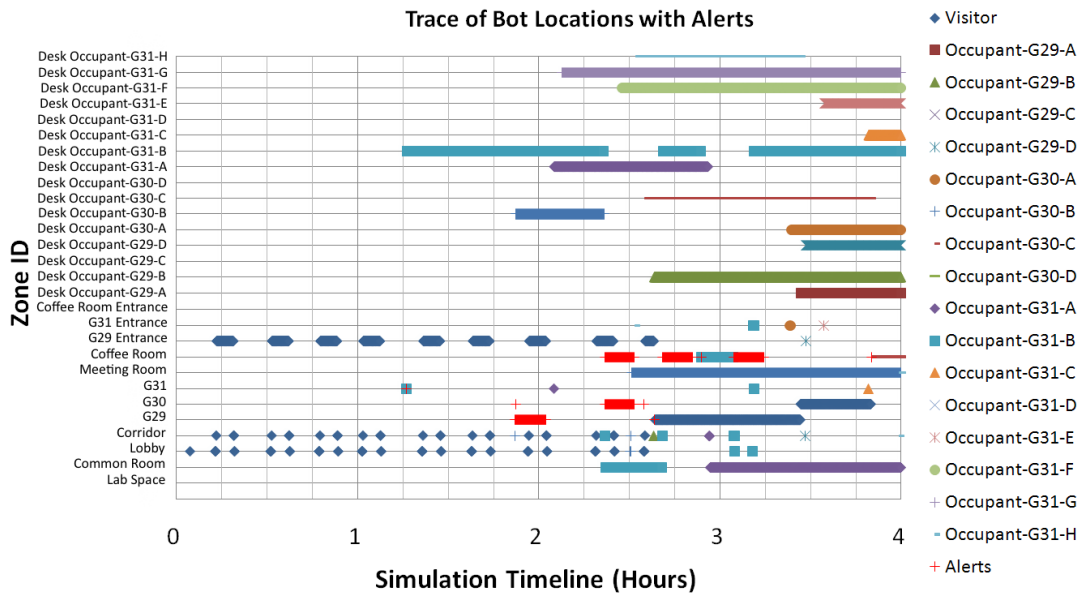


Figure I.34: Charted alerts for situation A2 : *Lights on unnecessarily*.

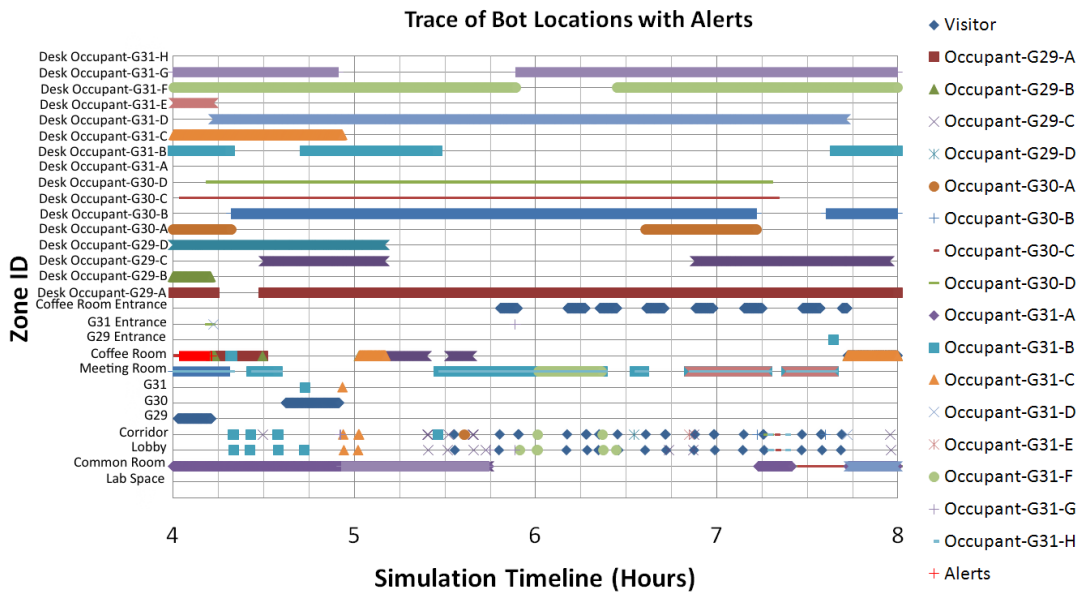


Figure I.35: Charted alerts for situation A2 : *Lights on unnecessarily.*

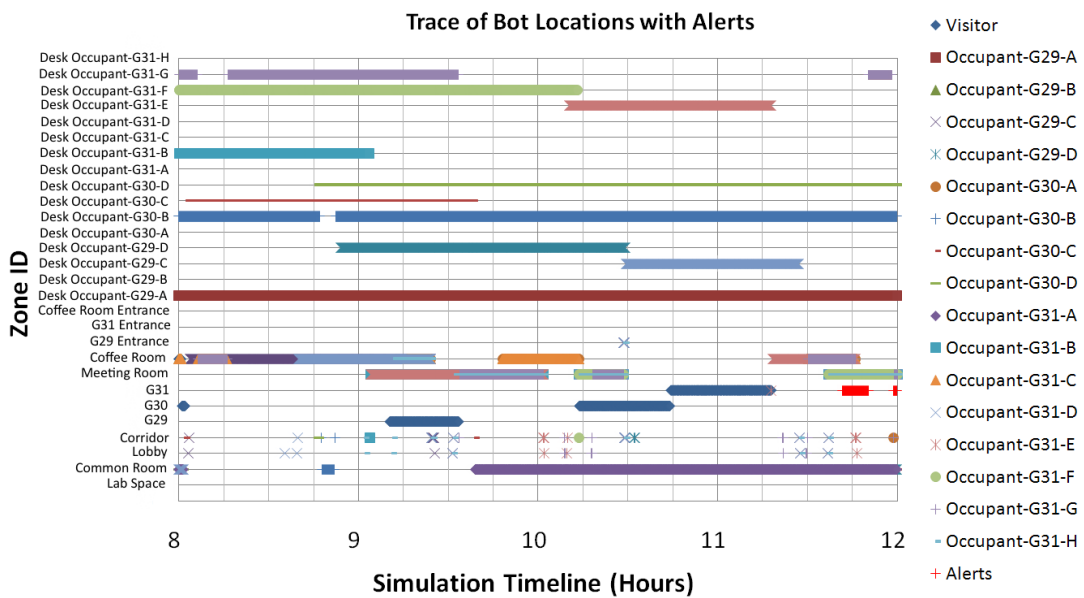


Figure I.36: Charted alerts for situation A2 : *Lights on unnecessarily.*

Traces of Device Events

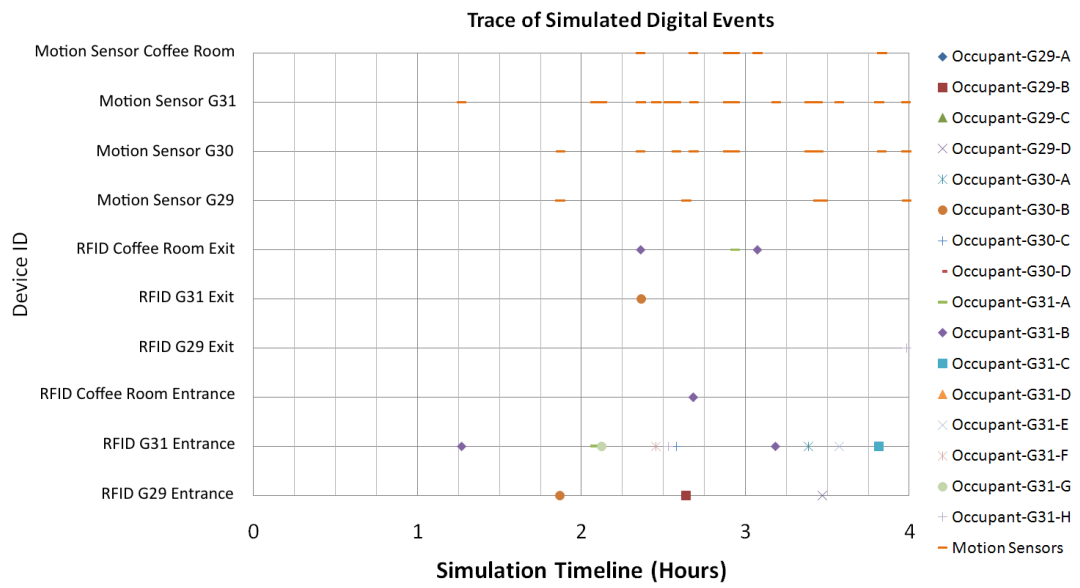


Figure I.37: Trace of device events.

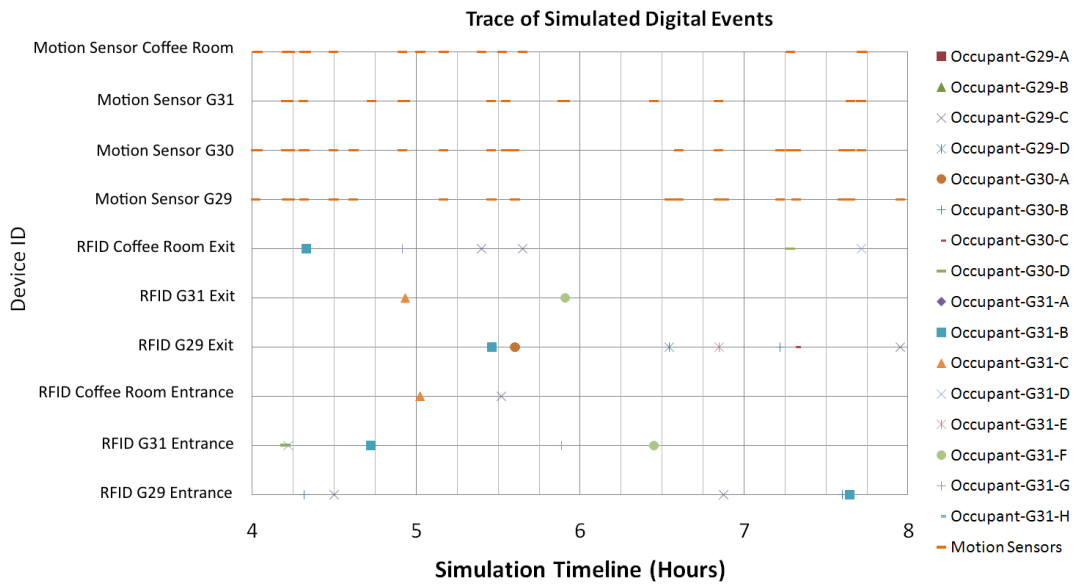


Figure I.38: Trace of device events.

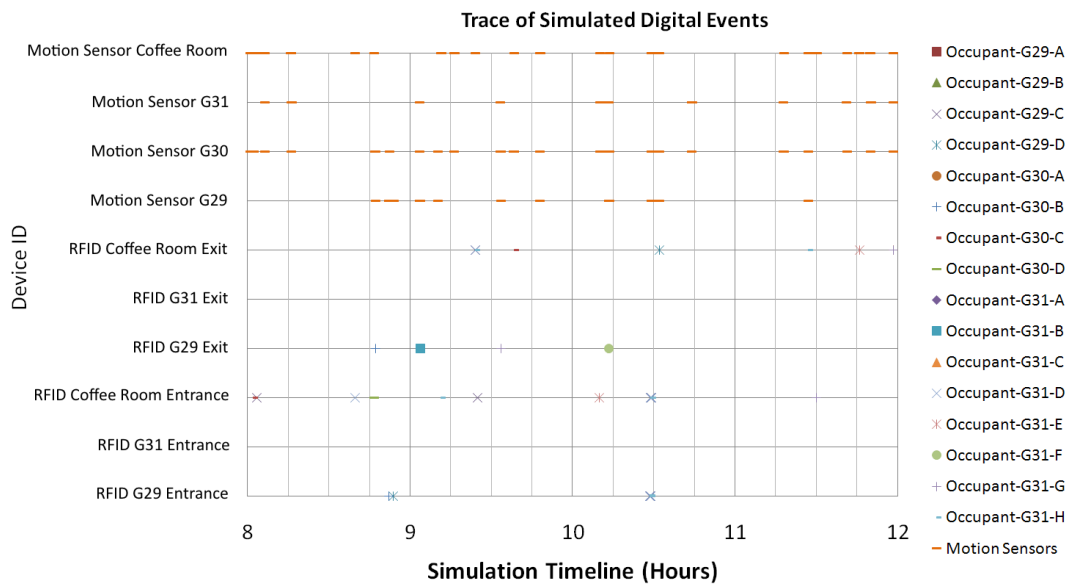


Figure I.39: Trace of device events.

I.1.3 Simulation 3: RFID, Motion Detection and Proximity Sensing, with Lighting

This section presents the results for the case study simulation that featured RFID, motion sensor and proximity detection access control, along with the lighting system from the first case study. The section begins with a chart that summarises all detected situational instances and follows up with spatio-temporal traces for individual situation specifications.

Summary of Detected Situations

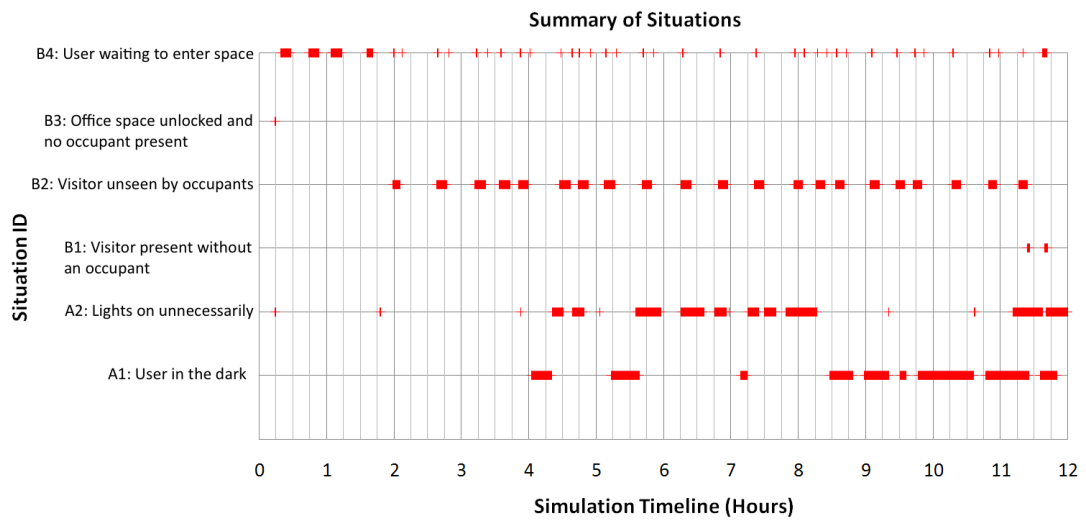


Figure I.40: Simulation 2 (RFID, Motion Detection and Proximity Detection): Summary of detected situation instances.

Situation B1: Visitor present without an occupant.

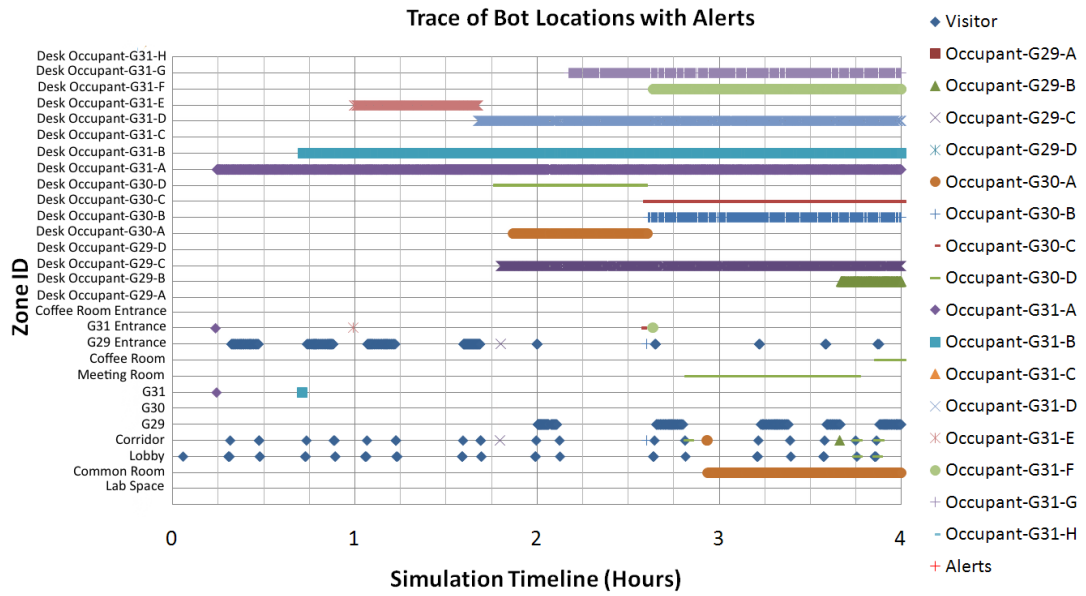


Figure I.41: Charted alerts for situation B1: *Visitor present without an occupant.*

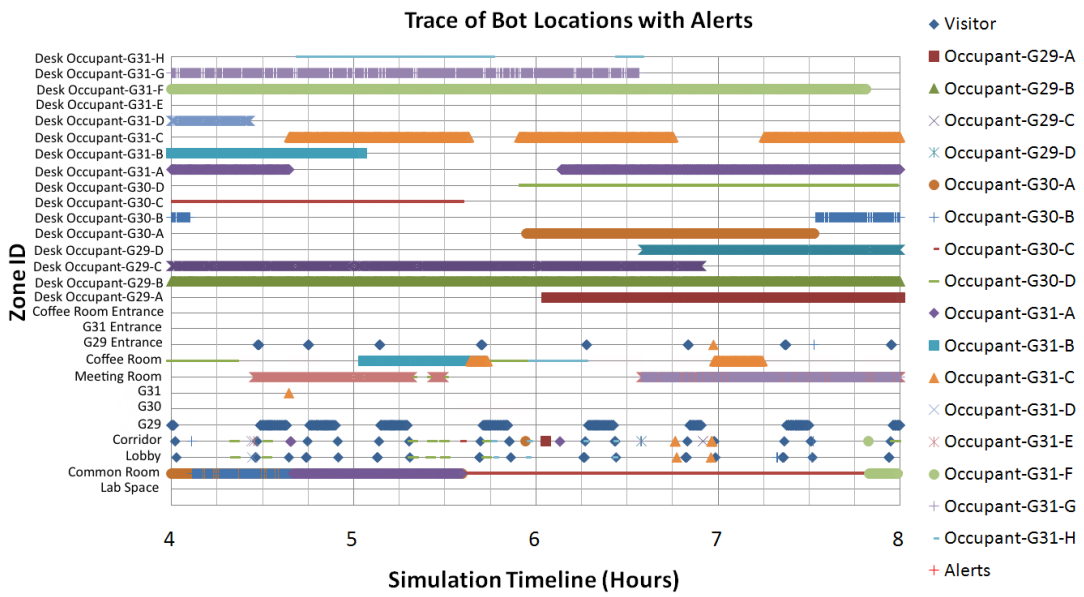


Figure I.42: Charted alerts for situation B1: *Visitor present without an occupant.*

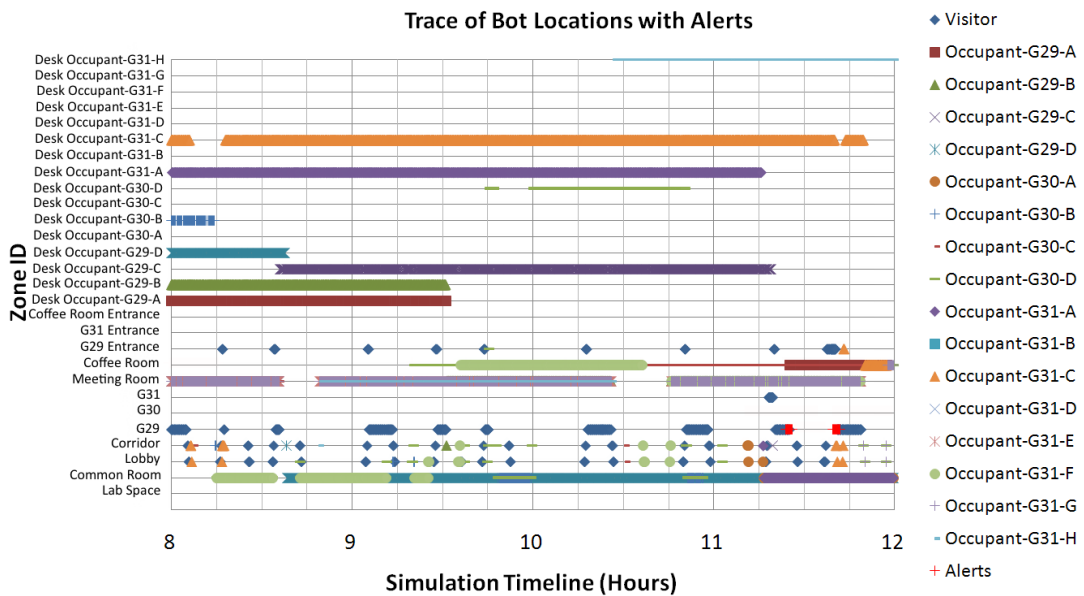


Figure I.43: Charted alerts for situation B1: *Visitor present without an occupant.*

Situation B2: Visitor unseen by occupants.

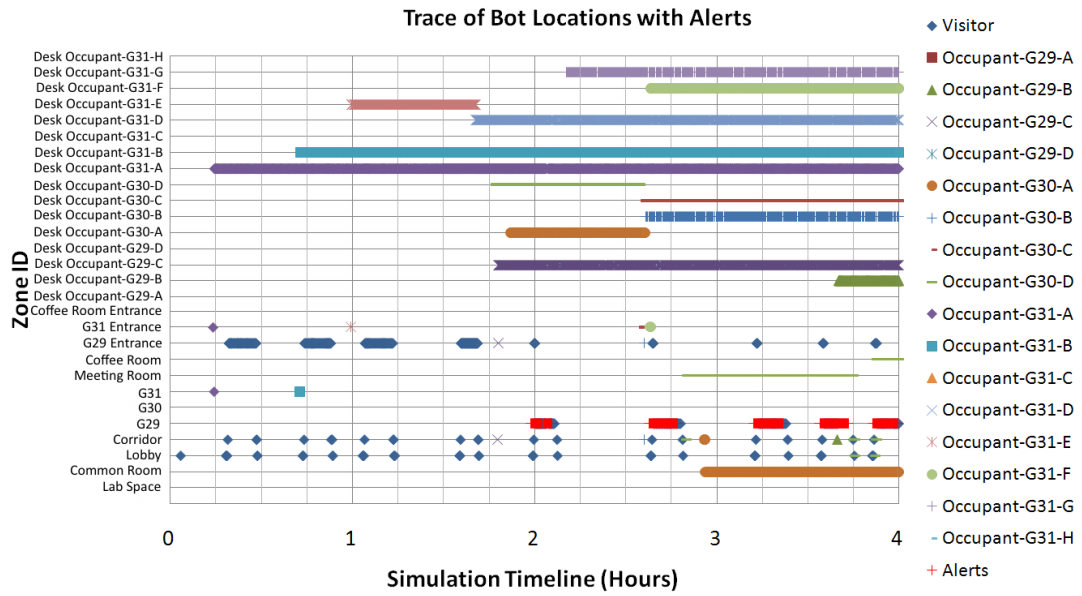


Figure I.44: Charted alerts for situation B2 : *Visitor unseen by occupants.*

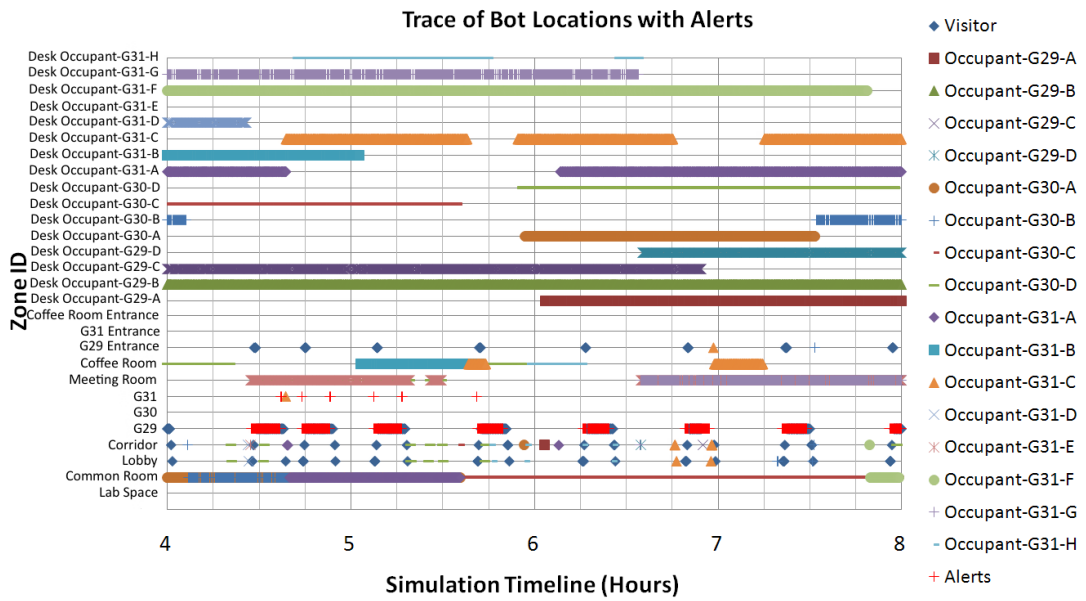


Figure I.45: Charted alerts for situation B2 : *Visitor unseen by occupants.*

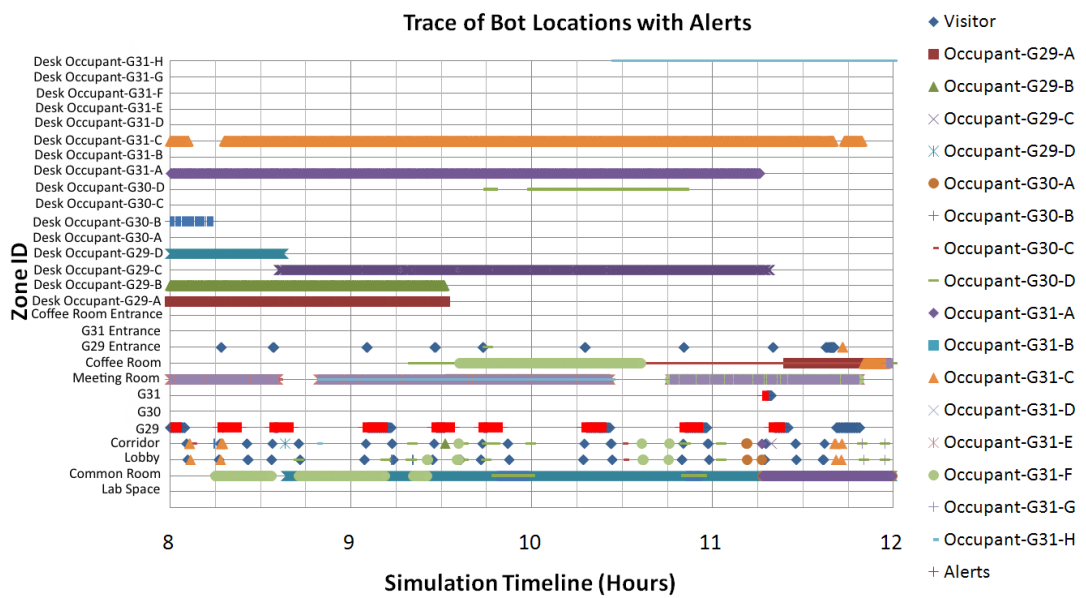


Figure I.46: Charted alerts for situation B2 : *Visitor unseen by occupants.*

Situation B3: Office space unlocked and no occupant present.

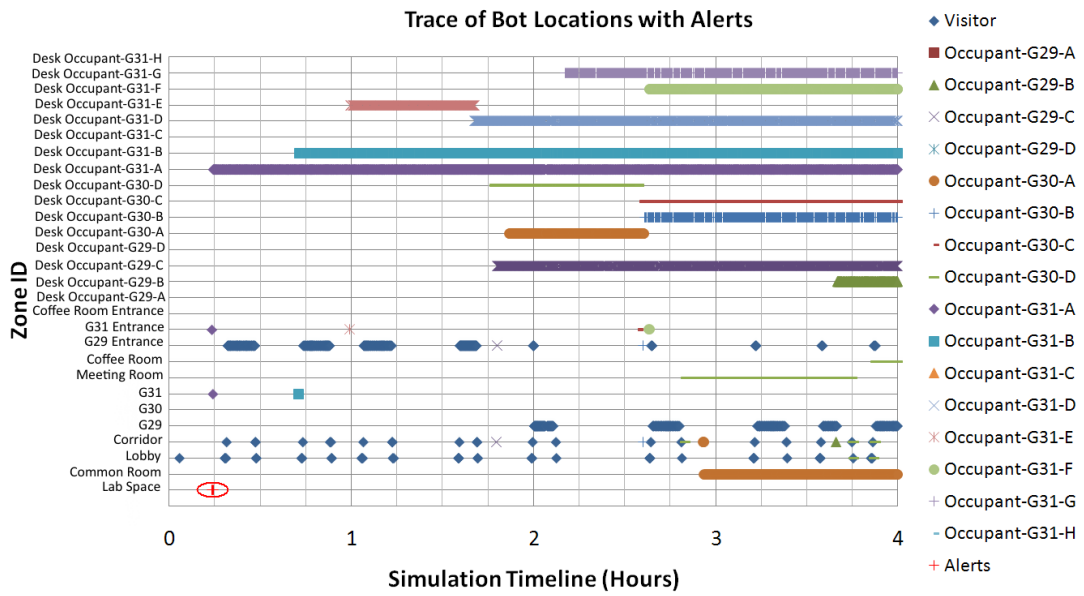


Figure I.47: Charted alerts for situation B3 : *Office space unlocked and no occupant present.*

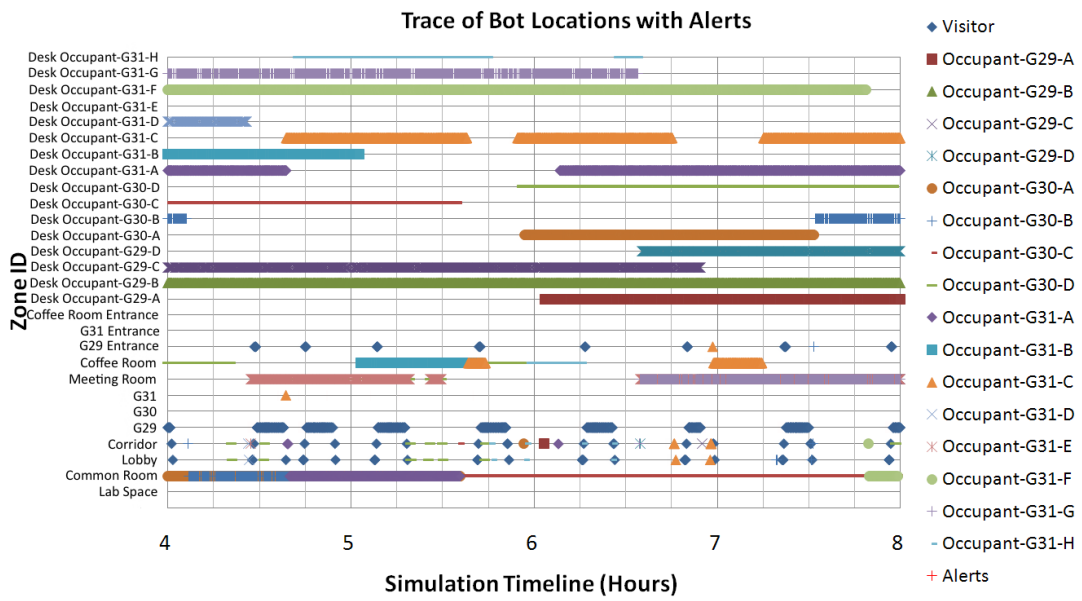


Figure I.48: Charted alerts for situation B3 : *Office space unlocked and no occupant present.*

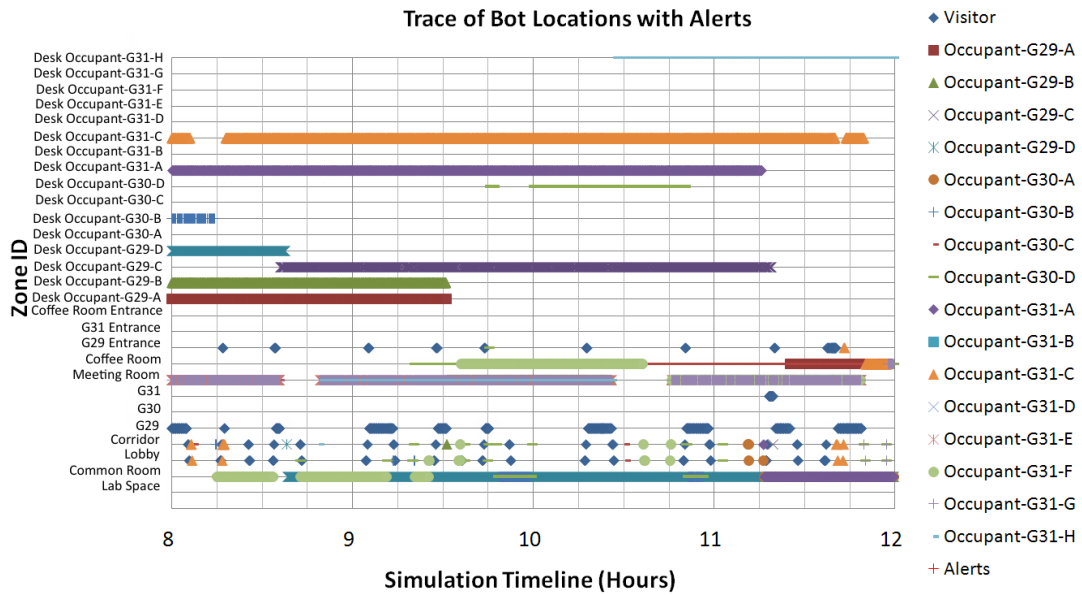


Figure I.49: Charted alerts for situation B3 : *Office space unlocked and no occupant present.*

Situation B4: User waiting to enter space.

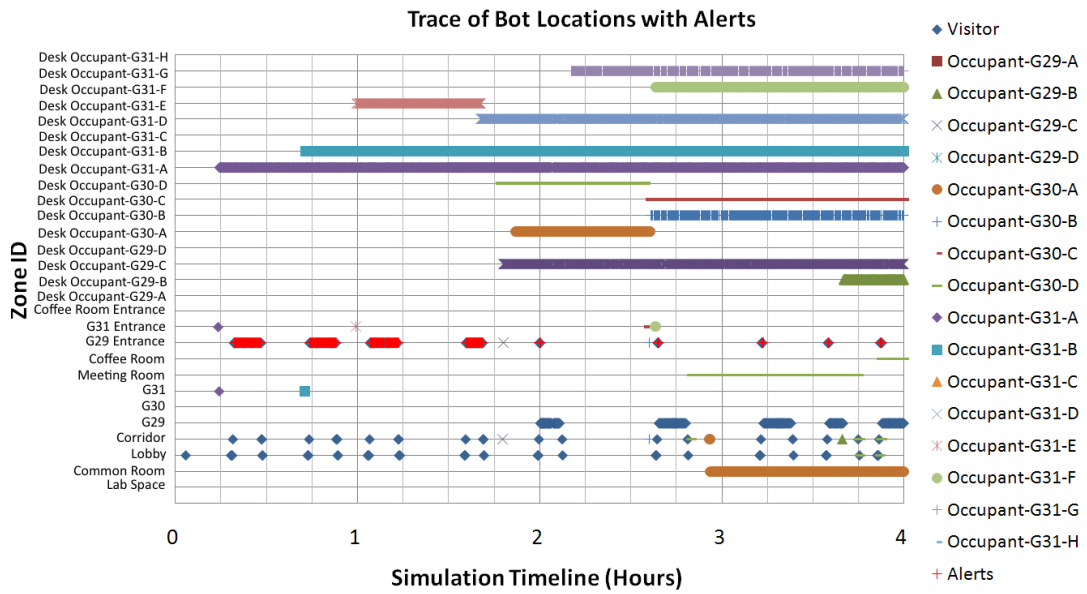


Figure I.50: Charted alerts for situation B4 : *User waiting to enter space.*

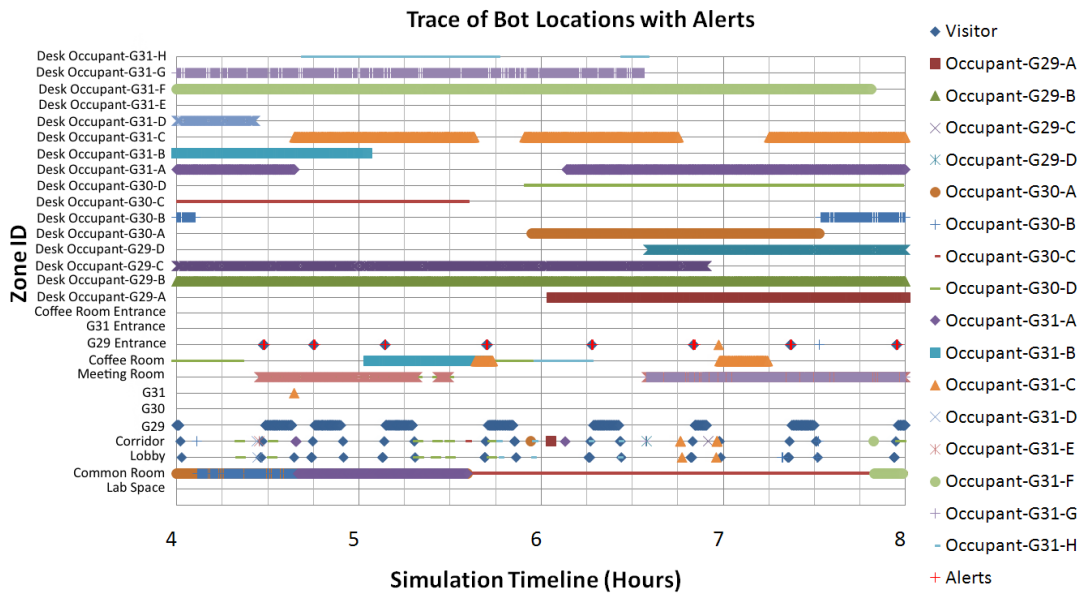


Figure I.51: Charted alerts for situation B4 : *User waiting to enter space.*

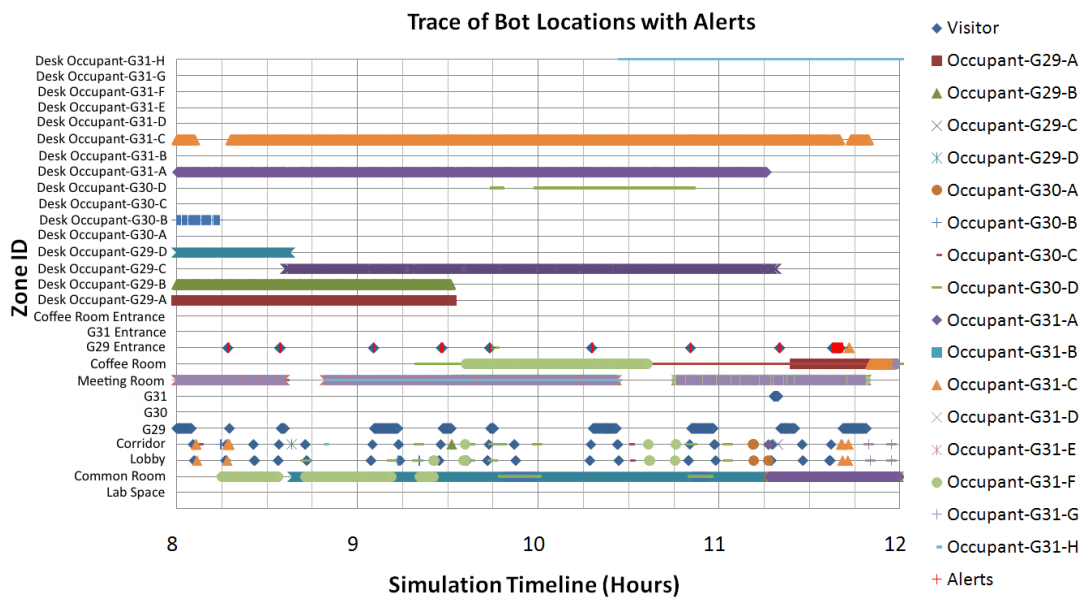


Figure I.52: Charted alerts for situation B4 : *User waiting to enter space.*

Situation A1: User in the dark.

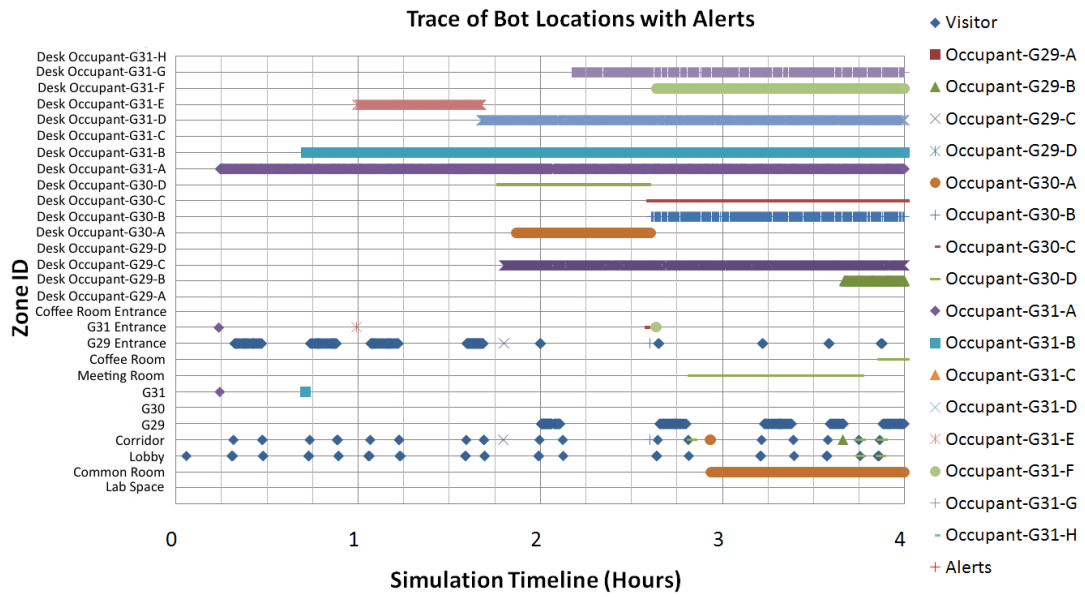


Figure I.53: Charted alerts for situation A1 : *User in the dark.*

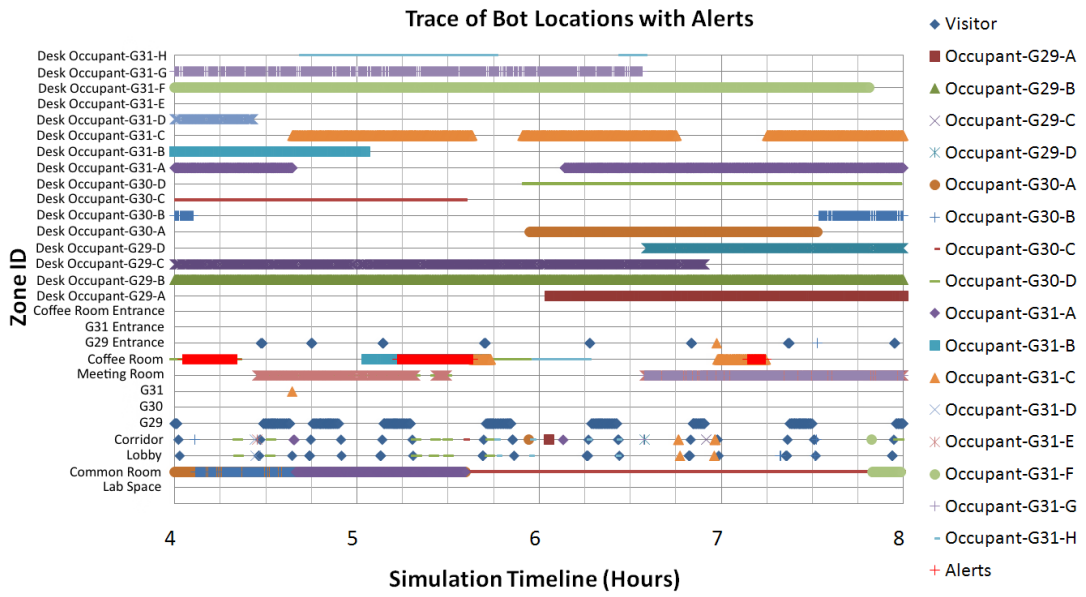


Figure I.54: Charted alerts for situation A1 : *User in the dark*.

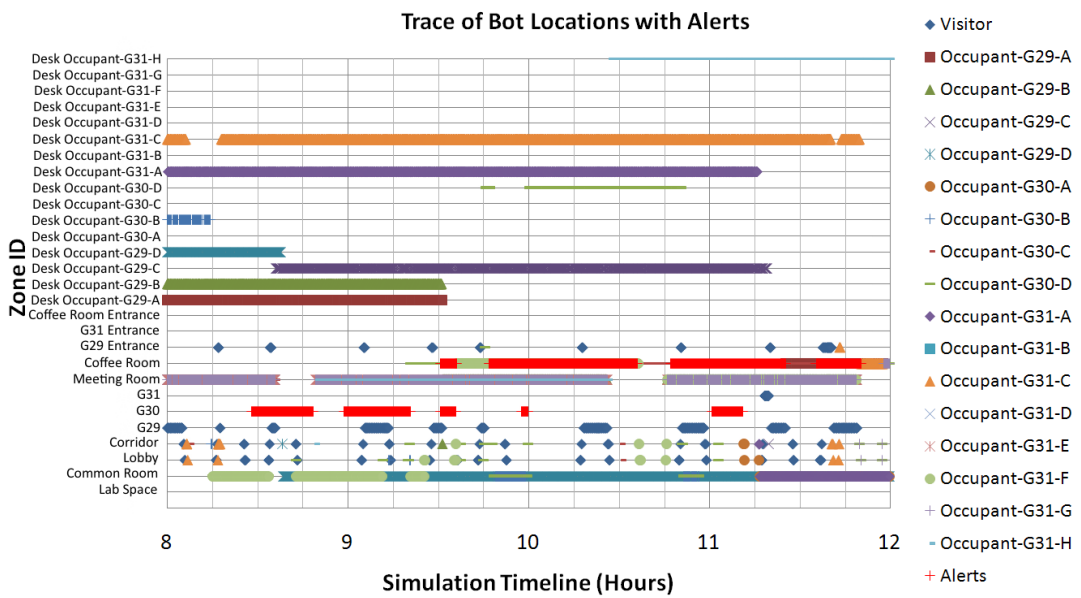


Figure I.55: Charted alerts for situation A1 : *User in the dark*.

Situation A2: Lights on unnecessarily

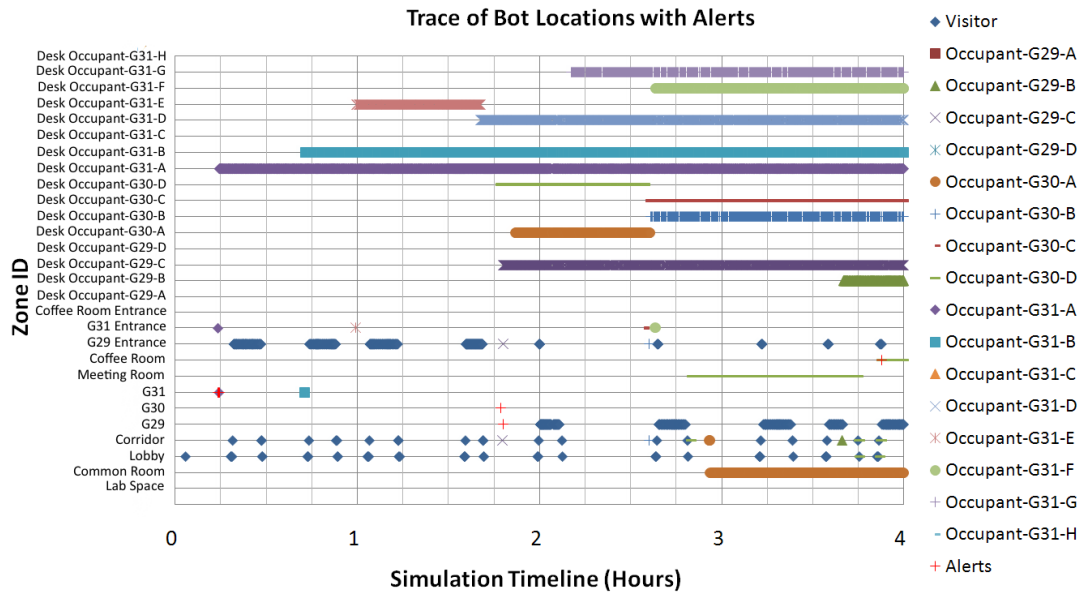


Figure I.56: Charted alerts for situation A2 : *Lights on unnecessarily*.

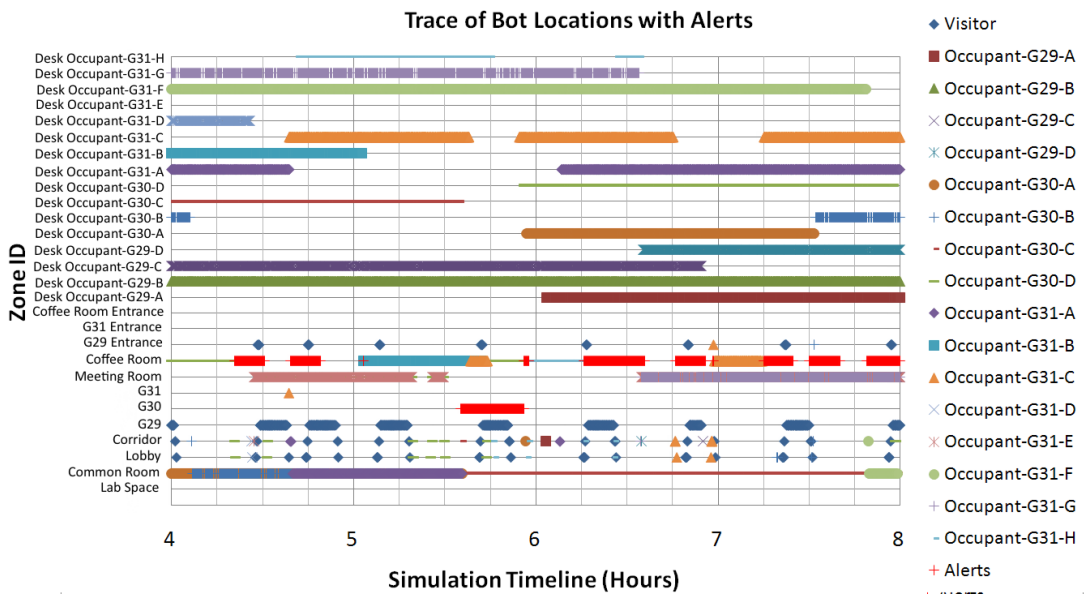


Figure I.57: Charted alerts for situation A2 : *Lights on unnecessarily.*

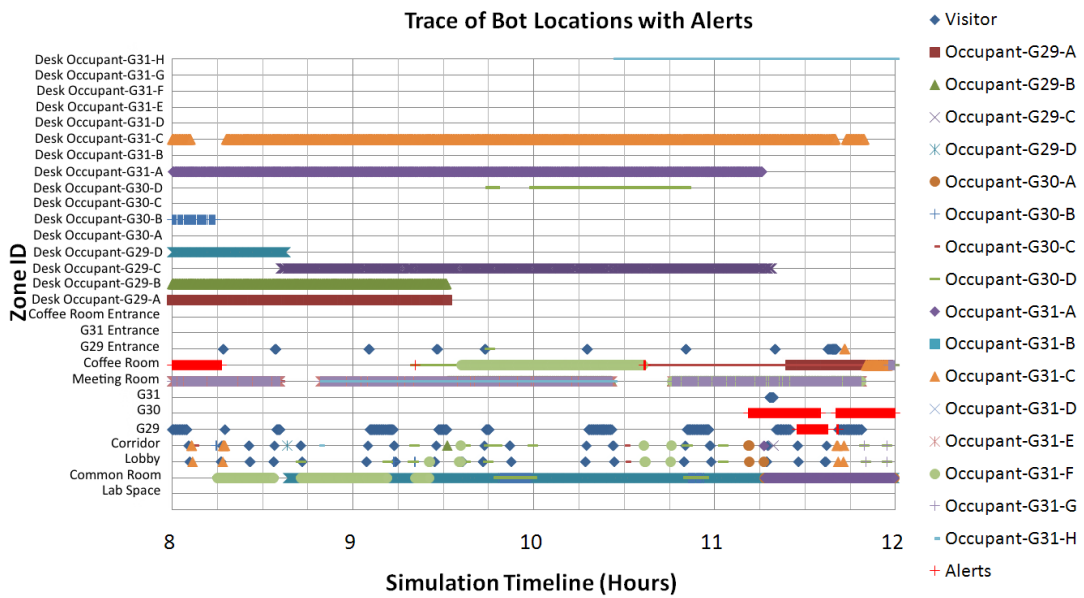


Figure I.58: Charted alerts for situation A2 : *Lights on unnecessarily.*

Traces of Device Events

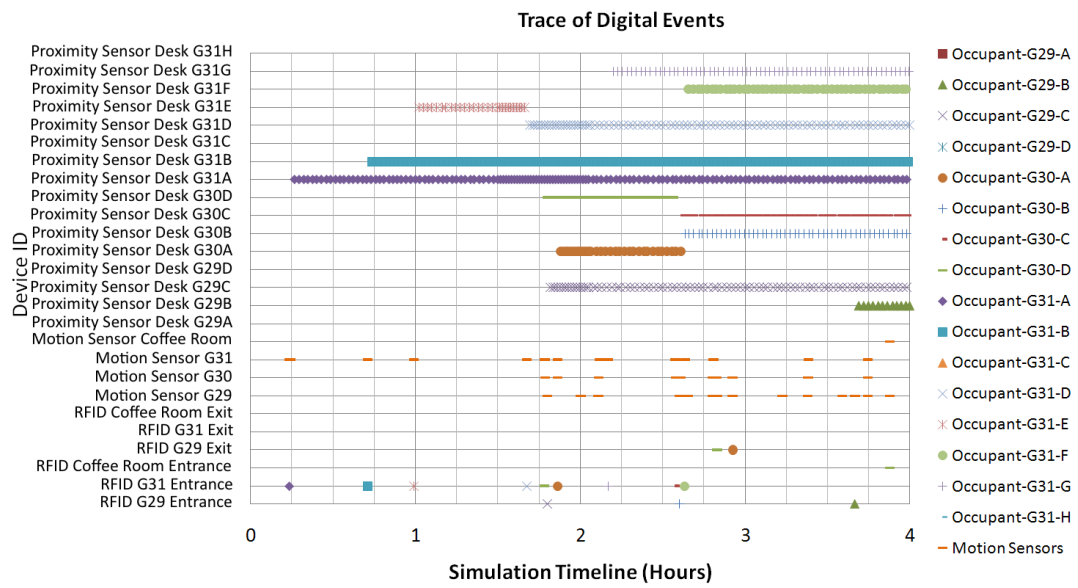


Figure I.59: Trace of device events.

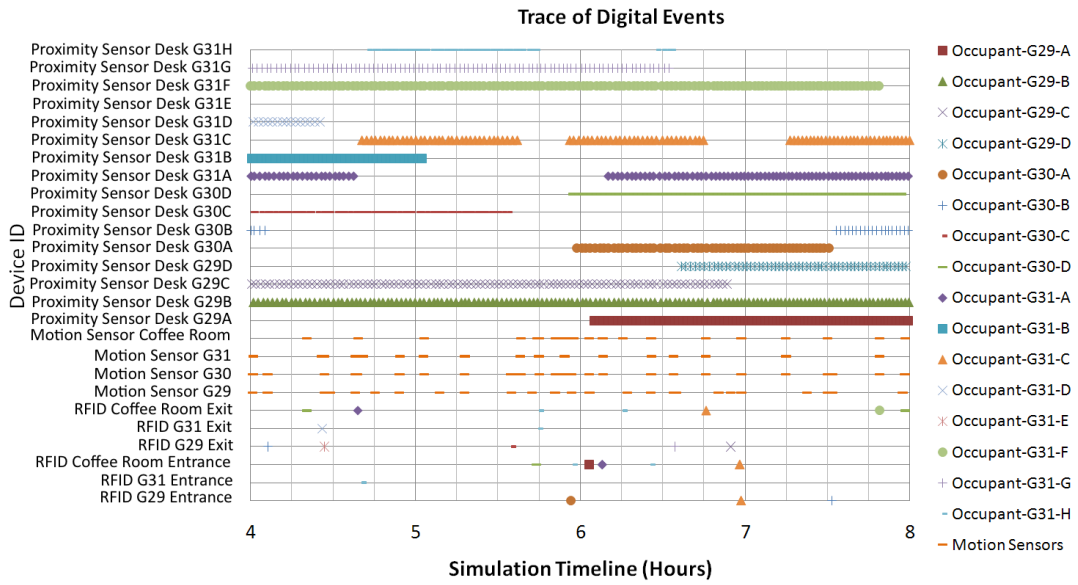


Figure I.60: Trace of device events.

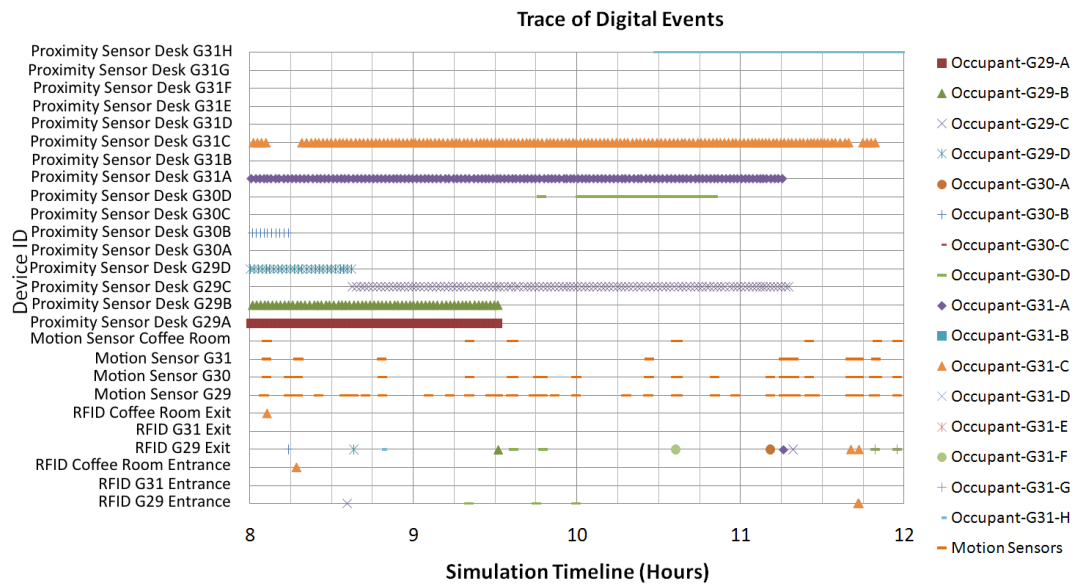


Figure I.61: Trace of device events.

Appendix J

Sample User Trial Charted Alert Report

This appendix provides a sample charted alert report, which was provided to participants in the user trial as the basis for capturing responses to the post-simulation questionnaire. Please click on this link to open the sample document: [[Link to sample document: SampleUserTrialResults.pdf](#)].

Appendix K

InSitu Demo Video

Please click on this link to view the InSitu demo video for the lighting case study presented in Chapter 6: [[Link to run InSitu demo video](#)]¹. Alternatively open the AVI file directly from the CD accompanying this thesis.

¹This video is also available at: [<http://www.youtube.com/watch?v=imvkKnhNdVM>].

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